POWER PLANT ENGINEERING

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The Great Mexican Cold Strike

You've all heard of this thing called suspended animation? Well, this is one of the few actual photographs ever taken of a case of suspended animation in action. As you will note, these two lightning flashes don't appear to be moving very fast. The fact is they were hot and were wishing for something cool. The sun dodger with the pile of nuggets around his neck is little Carlos Ortego, "the twice." They call him that because he is twice as slow as his boy friend in everything except quitting at night. He posed for this picture unconsciously during a rush period in his life, a ten minute exposure with a slow motion camera being all that was necessary. The other statue is Notso Hotsie, "the third," so named because he was the last of a long line of triplets.

As we said, they were hot. Well, one day after indulging rather freely in a mess of Mexican jumping beans, Carlos and Notso both happened to move at the same time, accidently of course, but the shock was so great it brought on a pair of brainstorms which resulted in their being placed in the cooler for an indefinite period. Here they became popular with the boys in the refrigerating room and soon became known as CO_2 and NH_3. What happened to them after that we do not know but they probably remained in their new environment for a long time. Cold, you know, implies absence of motion and at this the boys were past masters. So it was that a pair of ninth rate conveyors were transformed into first rate refrigerating mediums.

Whether the idea got its start here or not, we don't know, but the fact remains that some bright genius did hit upon the idea of combining CO_2 and NH_3 into one refrigerating system with most excellent results. This, however, is another story and though we present the basic principles involved on page 477, we refer you to page 495 for the real details.

WITH THE EDITORS

Power Interchange

SHOULD THE PRIVATE industrial power plant be considered and treated as a competitor or as an ally? Or from the other side, is the public utility an enemy or ally of the industrial plant? The question is, we believe, one of the major issues facing the power companies of this country.

There is no denying the fact that under certain conditions industrial plants can make power at two to three times the thermal efficiency of the best central station. By going to higher pressures and temperatures, many of them could supply a considerable quantity of power to the utility systems.

For six or eight years the more far-sighted utility engineers have recognized and discussed this possibility yet in few instances have executives seen fit to encourage interchange. In fact, the industry as a whole has ignored the issue, treating it as a skeleton in the closet which everyone knows about but will not speak of.

Yet the active campaign to track down and bag industrial plants, the recent rush to build joint plants and plants to serve a single industry; the interest in buying or managing industrial plants and the secrecy thrown around the many interchange agreements are evidences that the utility companies are not ignorant of the modern industrial trend and the menace it offers the old competitive code.

The issue is up to the executives of the power industry as a whole and individual operating companies should not be left to help themselves out of embarrassing positions into which they will be forced with increasing frequency.

Undoubtedly there will always be a considerable amount of "each case must be considered individually," yet it must be remembered that the better industrial companies are not in the mood to sell their power as dump power for the fuel increment of the utility power costs. Perhaps the most logical basis of exchange is that used by some of the power companies among themselves, that is splitting the production cost differential between the two companies equally.

This may be a complicated arrangement in the case of an industrial plant, yet one not impossible to overcome between two companies working on a cordial and non-competitive platform.

At present the industrial plant has a bright outlook. Industries have not lacked competent engineers to handle their own production problems but there has been lack of independent engineers familiar with the utility side. This has now been taken care of to a large extent by the wholesale breaking up of utility engineering organizations in all parts of the country.

These men, trained by a life time of power system design and operation, can turn their professional ability to make a job for themselves in the fertile industrial field, which has as yet only been scratched. The utility knowledge and experience of these men combined with the industrial knowledge and experience of present industrial engineers is likely to checkmate the competitive relationship heretofore existing. We believe that the next move is up to the executives of the public utility industry.

New Lubrication Facts

WORK OF THE Lubrication Engineering Committee of A. S. M. E. has produced a new theory of the mechanism of lubrication, which proposes novel bases for valuing oils and greases as lubricants.

New features in the behavior of lubricants have been discovered by tests on a machine erected by Sperry Gyroscope Co., supporting the discoveries of Viewig, a German investigator, that viscosity is not a guide as to lubricating value. Langmuir's theory that a layer of oil one molecule thick is held at the faces of metals by chemical forces, also the theory of French investigators backed by J. J. Thompson that a heavy layer of oil is held to metal faces by electrical or magnetic fields are given support, since the test machine not only confirmed the presence of these layers but peeled off layer after layer down to a last layer which did not peel off even under application of enormous disruptive forces. Even if this ultimate layer was wiped off, a new layer was immediately created. For a steel surface, as many as 21 layers of oil have been wiped off, where before even a single fluid layer has never been suspected.

Briefly, the new theory indicates that a layer of oil is formed on the surface of metal, the thickness and strength being determined by characters of the metal and lubricant. In accord with latest conceptions of absorption, this layer pumps oil into the crevices of the metal, under enormous pressure. The free film plays no part in separating the metal surfaces of journal, balls, rollers, or plates and bearings; that separation is maintained by the adhering layers of lubricant, which, if wiped off, are immediately restored by oil ejected from the crevices of the surfaces. This means that all lubrication is essentially high-pressure lubrication.

Tests give serious intimation that many, if not all, lubricants consist of two parts, one performing the lubricating function, the other acting as a colloidal solvent for the first. Present measurement of viscosity gives values of the two jointly whereas, if viscosity has any bearing on lubricating value, it is the viscosity of the lubricating constituent which counts, not that of the solvent. Tying viscosity, as now measured to lubricity, is thus placed under suspicion until true viscosity of the lubricating component is determined.

Present day speeds and bearing loads in machinery make necessary precise knowledge of the behavior between metals and lubricants, also selection from the many kinds of lubricants available necessitates rapid and reliable testing methods to permit wise decisions. A clear picture of the mechanics of lubrication is needed and the tests which have been reported by William F. Parish and Leon Cammen seem to be a step toward clarifying our knowledge.

Suggestions for Profitable Reading

The "Low Down" on pH

When we first came across that mysterious combination of letters, pH in certain technical articles not so very long ago, we assumed that it was a typographical error and put the blame on the printers—publishers always delight in blaming the printers, you know. Whether we had an argument with them or not, we don't recall, but soon we found more of these pH's in the literature and the mystery thickened. About this time, we recalled to memory the resourcefulness of that enterprising town, Salome, Arizona, as recounted by one Dick Wick Hall in the Saturday Evening Post. What Salome lacked in size it made up for in importance. Well, it seems, they ran a paper down there —the Salome something or other, we don't remember— but anyway, one day in setting up a story about a fire, they ran out of "f's". There wasn't another "f" left in the one and only printing office in town. In any other place this would have been dire calamity but not so in Salome. With its characteristic resourcefulness, the staff substituted "ph" wherever an "f" was needed and thus saved the situation nicely. That night the Salome Gazette came out with the startling headlines— "Phire Phighters Battle Blaze at Philling Station."

So when we first saw so many pH's scattered through articles on feedwater we thought maybe the printers had run out of "f's" but upon more serious reflection this seemed absurd so we merely continued to wonder.

Soon it appeared, however, that this pH had to do with a new kind of chemistry—a kind we never had been taught in school. When we went to school we learned that water, for instance, is composed only of molecules—molecules of H_2O. Today it appears this is no longer true; in addition to molecules of water there are also separated parts of these molecules called ions, and the pH has something to do with these ions. For a while we let it go at that; we even talked learnedly about ions and pH values, without really knowing what it was all about but then nobody else did either.

Then, one day we heard a lecture by S. E. Tray on the practical essentials of feedwater treatment and there our eyes were opened; as they say in the movies, "then came the dawn." We began to see what this pH business was all about. Well, to make a long story short, we were so enthusiastic about this lecture that after it was over we went to see Mr. Tray and obtained his permission to use the substance of it in an article which we present in this issue. Read it. Perhaps your boiler water is "Okay," perhaps your system of water treatment is all you desire, maybe you haven't any boilers to worry about; never mind, it doesn't matter, read the article anyway.

Twins in Refrigeration

We don't like chemistry any more than you do, but you ought to know something about it, and that reminds us,—while we are on the subject, what do you make of

$$NH_3 + CO_2 = ?$$

Ammonia plus carbon dioxide equals what? Well, one chemist will tell you one thing and another something else but as far as we are concerned, they are all "haywire." To us $NH_3 + CO_2$ equals only one thing and that is a corking good refrigerating system.

What do we mean? Simply this: When we combine an ammonia refrigerating system with a CO_2 refrigerating system we get an arrangement which possesses the advantages of both and the disadvantages of neither.

Now, don't jump at conclusions; this scheme isn't nearly as crazy as it sounds. We are not planning to fill a single system with both ammonia and carbon dioxide—we still propose to have separate systems.

The vapor pressure of ammonia at temperatures of minus 30 to 40 deg. F. is below atmospheric pressure. For this reason, with equipment subjected to a vacuum and handling large volumes, the ammonia system is not as desirable for very low temperatures as is, say, CO_2. This latter refrigerant, however, has the disadvantage of high pressure at the usual condensing water temperatures. So by combining the two systems, using CO_2 for the low temperatures and ammonia for the high temperatures with a heat exchanger between, the advantages of both refrigerants can be obtained in the field for which they are fitted.

There—we didn't intend to tell you all this here, but there are still some things in the article on page 495 which we haven't mentioned here. The heat balance diagrams alone are worth studying.

A Warmer Outlook

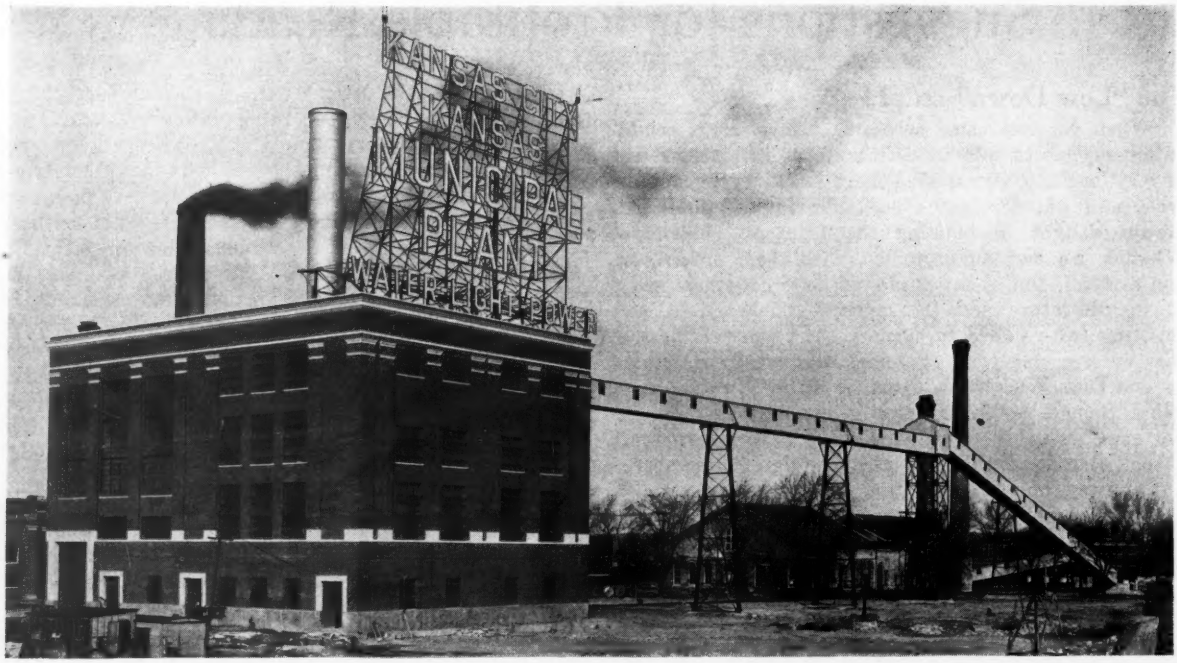
To change the subject, let's talk about something warm, re-heat for instance. Time was, when we made steam in a boiler and sent it to an engine or turbine, we were content to let it go at that,—to allow it to find its way to lower temperatures. The modern engineer, however, thinks this entirely too simple; he insists upon piping it back to the boiler room and re-heating it one or more times.

A few years ago re-heat was quite simple but in the five years or so that it has been with us, many different schemes for re-heating have been developed. These various methods are described in an article on page 484.

Now, it may be that you are not directly interested in re-heat but, if you want to keep up with progress, this article, which by the way is one of a series on this subject, should be of value to you. Temperature, it appears, is of greater importance than pressure in increasing efficiency and because of this, re-heat promises to occupy an important place in future development.

Getting Bigger as They Grow Smaller

That's what mercury arc rectifiers are doing these days. If you don't believe it, turn to page— and see for yourself. As pointed out there, this seeming paradox is quite simple, as the rectifiers get bigger electrically, they get smaller mechanically. A new 750-kw. sectionalized rectifier for instance is only two thirds as large as a conventional 500 kw. unit. These rectifiers are so constructed that small units can be stacked in banks, like cans of soup on a grocer's shelf. Four 750-kw. units mounted two high and two wide for instance form an extraordinarily compact 3000-kw. unit.



100,000-Kw. Kansas City Municipal Plant

Kansas City, Kansas, Municipal Plant With an Ultimate Capacity of 100,000 Kw., Starts Up First 10,000-Kw., 400-Lb., 250-Deg. F. Superheat Unit. Circulating Water Used Later in City Water System. By R. L. Baldwin of Burns & McDonnell Engineering Co., Kansas City, Mo.

FOR A NUMBER of years the municipality of Kansas City, Kansas, has operated its own water works system and electric light and power system and has been particularly successful. Water is obtained from the Missouri River, and is properly purified for domestic consumption and industrial use. The same power plant furnishes power for pumping as well as for electric light and power service.

The city has large industries, packing plants, soap plants, structural steel fabricating plants and tank works, mills and elevators, railroad shops and yards, and numerous minor industries. The power plant has a high load factor with a summer peak load almost equal to the winter peak. This power plant serves all of these industries except where the need for process steam makes it more economical for industries to supply their own power.

Industries require reliable power and every precaution has been taken to insure continuous service. Attractive rates are in effect so that these industries are benefited by using this power and other industries are being attracted. Ample water supply and power at low rates are necessary for industrial development.

In 1929 the city placed a separate Board of five business men in charge of these two utilities. It was known that additional power plant capacity was needed and this Board took immediate steps to secure the necessary capacity. First, a study was made of the past history and a comprehensive plan for the future development worked out. This plan called for a complete new power plant to replace gradually the old plant which had grown to its economical limit and which was not nearly as efficient as the more modern boiler and generating plants which have been developed in recent years. The new plant will have an ultimate capacity of 100,000 kw. It will be located alongside the old power plant and will make use of the old intake for circulating water.

The first unit has now been placed in operation. It consists of one 10,000-kw. turbo-generator and one steam

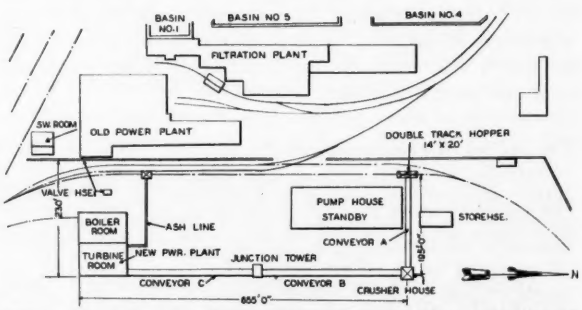


FIG. 1. PLAN OF THE GROUNDS SHOWING RELATIVE LOCATION OF OLD AND NEW PLANTS

generating unit with a capacity of 150,000 lb. of steam per hour and will be able to furnish 180,000 lb. of steam per hour for 4 hr. Present steam demands run up to over 300,000 lb. per hr. so that this new boiler can supply a large portion of the steam needed and can carry one-half the load even during peak demand. Steam pressure will be 400 lb. gage at the turbine throttle, with 250 deg. F. of superheat. A steam line will connect the two power plants using reducing valves and desuperheaters to reduce the excess steam generated over the amount required for the new turbine and its auxiliaries to the proper pressure and superheat for use in the old plant.

Steam is generated at approximately 420 lb. per sq. in. gage pressure, with a nominal total temperature of 700 deg. F. for use in the new plant. Part of the old plant steam requirement is supplied at 175 lb. per sq. in. and 478 deg. F. by the new plant through duplicate pressure-reducing valves and desuperheaters. Steam tion heater to the deaerators. Surge tanks are connected in just ahead of the latter. Condensate from the old plant is returned to the new plant in excess of the old plant boiler requirements, with provision for automatically using the new plant surge tanks for the old plant. The boiler feed pump suction and discharge headers are also ring headers with double sectionalizing valves and crossovers.

Make-up proportional to the use of the new turbine is introduced to the deaerators as steam, using the second and third bleed nozzles for heating and evaporating in a small open heater and evaporator. Make-up proportional to the use of the old plant and for emergency replacement of the turbine make-up system is obtained as 175 lb. 480 deg. F. steam by means of a heat interchange system or steam-to-steam boiler. Both make-up systems are controlled by floats on the surge tanks, whose capacity is nominally 20 min. full load operation.

Water for ash sluicing is provided from the con-

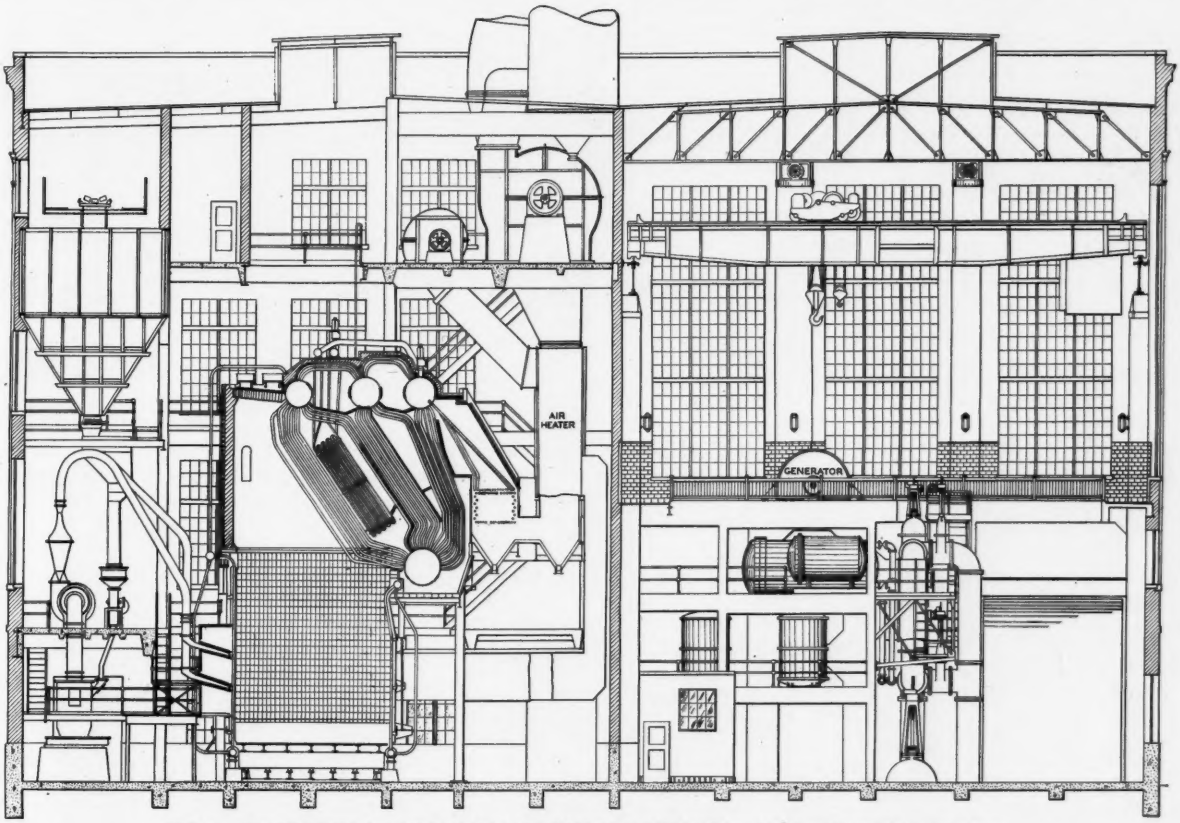


FIG. 2. CROSS SECTION OF PLANT AND BOILER AT KANSAS CITY MUNICIPAL PLANT

from the new and future boilers is introduced into a ring header equipped with double sectionalizing valves. Valved cross-overs will be provided in the future at every second boiler. The turbine and boiler gate valves are motor-operated by means of Limitorque controls. A plant auxiliary steam header is carried in parallel with the main steam header with connections to the main header every second boiler. All steam-driven plant auxiliaries are connected to this header as are the pressure-reducing valves.

Flow System

Turbine condensate passes through the air ejector inter and after condensers, and the low pressure extrac- denser discharge lines by means of a 1600-g.p.m., 150-lb. per sq. in. pump. The circulating water system is laid out for what will eventually be a 60-in. ring header with double sectionalizing valves. The condenser is provided with piping to enable reversal of flow while in operation. The discharge is carried to the water department basins with provision for bypassing unnecessary water to the Missouri River.

Generator will operate at 13,200 v. 3 ph. 60 cycles. The old generators are 2300 v., stepping up to 13,200 v. through transformers. The new generator will be tied to the 13,200 v. bus and will be controlled from the control room in the old power plant switchroom. The

control room will be moved to the new plant when the next turbine unit is installed.

Connection between the generator and the 13,800 v. bus is made with three 1500 m.c.m. single conductor type H cable carried in a fiber and concrete duct bank between the plants. The duct and the cable lines were so planned that they can be used as tie lines to connect the two stations together as soon as the new switchhouse is constructed.

Electrical Changes

Inasmuch as the present plant has grown so that no excess interrupting capacity of the oil circuit breakers was available, the connection of additional generating capacity to the present bus created a problem, as it was undesirable to replace the existing switch gear. In order to avoid overstressing the feeder breakers in times of severe short circuit, fifteen three per cent, 13,800-v. single phase reactors of the indoor dry type were connected in the feeder circuits. These reactors were installed in individual compartments in the space occupied by electrolytic type lighting arresters which were replaced with new outdoor type of autovalve arresters. All new oil circuit breakers added to the 13,800 v. bus as well as all breakers for the control of 2500 v. station auxiliaries in the new plant were selected to have rated interrupting capacities ample for a plant of 100,000 kw. capacity.

With the exception of the feeder motors on the boiler units, all auxiliary motors are supplied with power at 2500 v. or 480 v. Power for all auxiliaries in the new plant is obtained from the 2500-v. bus in the present station, and is brought to the new plant by means of duplicate sets of cables to a ten circuit cubical structure. In order to keep down the size of the breakers required in the structure, a five per cent, 2300-v., three-phase reactor was connected in each of the two cable circuits supplying the cubicle structure. Each cable circuit is large enough to carry the entire auxiliary load but will ordinarily only supply its section of the cubicle structure. Essential station auxiliaries are divided between the two sections. The cubicle structure is controlled from the present control room.

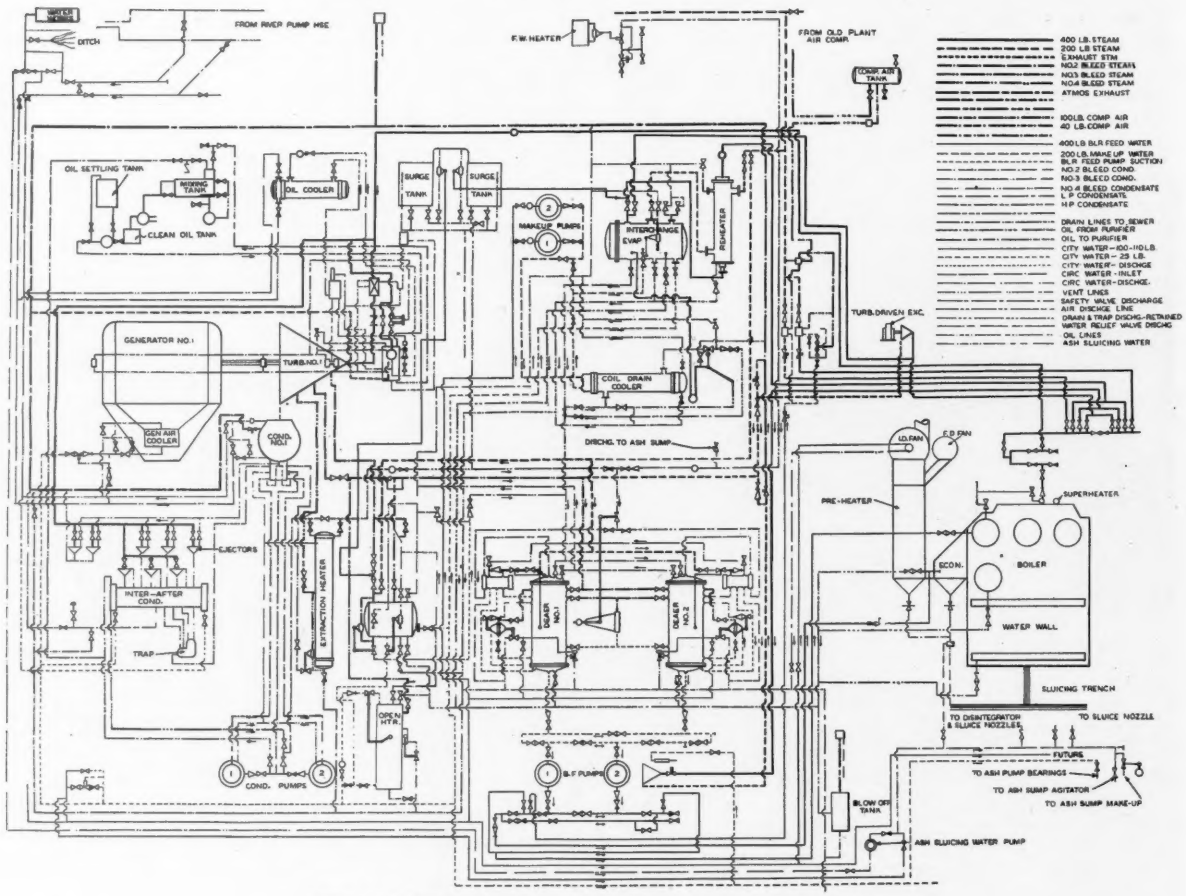


FIG. 3. COMPLETE PIPING DIAGRAM OF THE STATION

The 480 v. supply is taken from an outdoor station transformer group supplied from the cubicle structure. Duplicate banks of power transformers supply a dead front 480 v. air circuit breaker switchboard. One bank of transformers will ordinarily supply the 480 v. essential auxiliaries, the other the non-essential auxiliaries. The board is arranged to permit immediate transfer of the non-essential bank to the essential bus. The main breakers on the air circuit breaker board are controlled from a panel in the present control room. The small amount of d.c. power required by drag feeder motors, automatic boiler control and magnetic separators will ordinarily be supplied by a 20-kw. motor-generator set supplied from a circuit on the 480-v. air-circuit breaker

board. In case of emergency, the turbine-driven emergency exciter can be used to supply this power.

At the old power plant a K.W.H. is produced with about 31,000 B.t.u. It is expected that the new power plant will easily produce a K.W.H with 18,000 B.t.u., so that there will be a very large saving in coal. It is expected that the new units will be used as much as possible, carrying all of the base load and leaving the old plant to absorb the peak loads.

Originally the city planned to install the plant in the restricted space available and plans were so developed. After plans were well along it was found that the adjoining land belonging to the Kansas City, Missouri, Water Department was to be sold due to the abandonment of that pumping station and arrangements were finally made for the purchase of this tract of over 50 acres. This made it possible to have ample room for construction purposes, saved relocating tracks and circulating water lines, and simplified the construction problem generally. Plans were then pushed to completion as rapidly as possible. Grading contracts were let immediately, and the piling contracts followed. Large items of equipment were purchased first so that working drawings were available for the engineers in planning the building and general hook-up of the equipment.

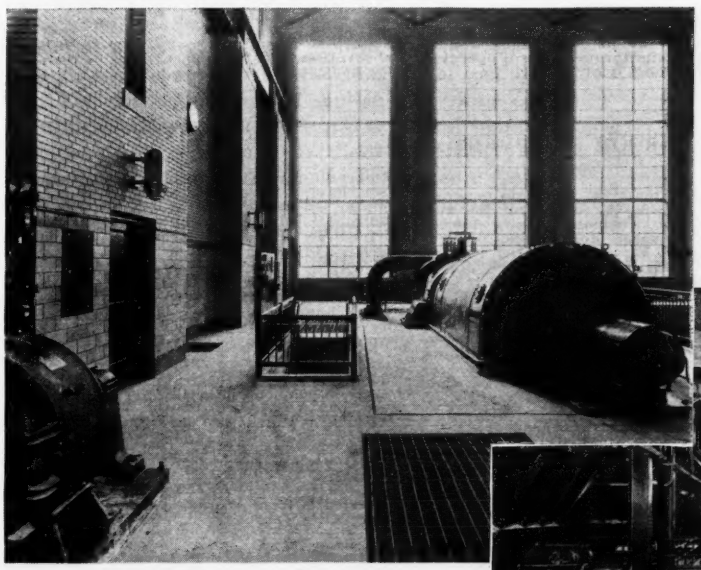


FIG. 4. THE 10,000 KW. TURBINE WITH THE STEAM DRIVEN EXCITER AT THE EXTREME LEFT

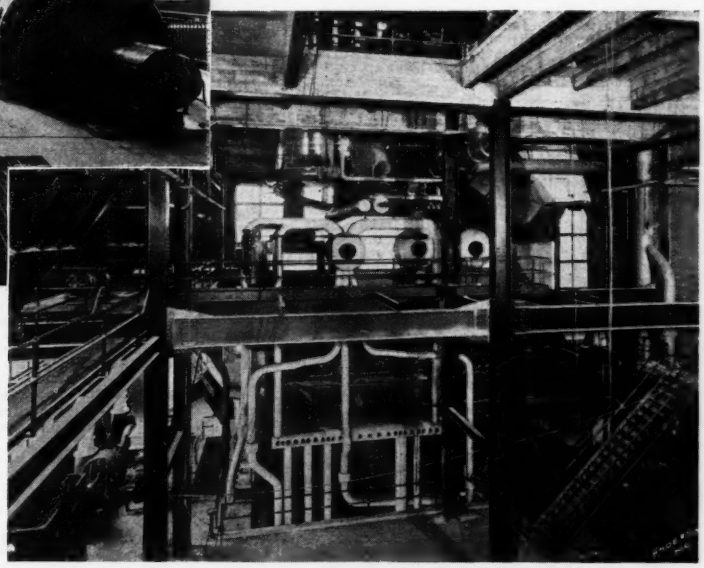


FIG. 5. ONE 150,000-LB. PER HR. BOILERS INSTALLED WITH SPACE PROVIDED FOR A SECOND

Circulating Water

One unusual feature is that of the use of the circulating water. Motor-driven pumps as well as a 50 m.g.d. steam-turbine-pump are available for this service. The circulating water requirement at all times exceeds the needs of the water works system. Water pumped from the river by pumps located in a special pit near the river first goes through the surface condensers and thence to the settling basins. A remote controlled valve allows the operator of the water works to control the level of the water in the settling basins by throttling the spill opening, permitting the excess water to flow back to the river. This requires some excess pumping head but saves in pumping and intake capacity. Estimates were made of costs for locating the condensers in a pit to cut the pumping head to a minimum, and it was found that the savings in power would not compensate for the excess cost of building construction. The added temperature proves to be an advantage in winter, and aid in chemical reaction; but, inasmuch as there is approximately 24 hr. time in the settling basin the added temperature is not particularly noticeable on the finished water.

There is no basement in the power plant. The first floor of the power plant, where condensers and auxiliaries, are located is above flood lines and on the same level as the operating floor of the old power plant. The turbine operating floor is 32 ft. above this level.

Coal Supply

Coal is delivered in hopper bottom cars to a track hopper 14 by 40 ft. It is then carried by a belt conveyor to a crusher house, and thence by belt conveyor

Principal Equipment Installed in Kansas City, Kansas, Power Plant

TURBINE ROOM EQUIPMENT

Westinghouse Electric & Mfg. Co., 1, 3600-r.p.m., turbine driving a 12,500-kv-a., 0.80 p.f., 3 ph., 60-cycle, 13,800-v. a.c. generator, with a direct-connected 250-v., 320-amp. exciter.

Westinghouse Electric & Mfg. Co., 1, 150-kw., 250-v. turbine-driven exciter, set for emergency use.

Griscom-Russell Co., 1, 4000-sq. ft., 2-pass, U-fin generator air cooler.

Schutte & Koerting Co., 1, No. 2-100X Type Z turbine oil cooler.

DeLaval Separator Co., 1, No. 360 De-Laval-Funk oil purification system.

Elliott Co., 1, 15,000-sq. ft., 2-pass, rigidly supported surface condenser, having 1 in. O.D. arsenical copper tubes 20 ft. long.

Elliott Co., 1, triple unit, 2-stage air ejector, with inter and after condenser, Elliott air meter and 2 single-stage starting ejectors.

Elliott Co., 2, 2-stage, 300 g.p.m., 125 ft. total head, 1150-r.p.m. duplicate condensate pumps, each driven by one 25 hp., 3 phase, 60-cycle squirrel cage induction motor.

Foster Wheeler Corp., 1, 498-sq. ft. low-pressure extraction heater having ½ in. O.D., 20 ft. long arsenical copper tubes.

Cochrane Corp., 2, deaerating heaters each having a capacity of 250,000 lb. per hr. with temperature of the exit water being that of the saturated temperaure of the heating steam and an oxygen content of not to exceed 0.03 cc per liter.

Cochrane Corp., 1, open heater having a capacity of 6000 lb. per hr. of city water heated to a temperature within 5 deg. F. of the saturation temperature of the heating steam, for make-up service in connection with

Foster-Wheeler Corp., 1, 198 sq. ft. horizontal evaporator supplying make-up as steam to the deaerators in proportion to the use of the 10,000 K.W. turbine generator. Coils of 1 in. O. D. arsenical copper tubing.

Foster Wheeler Corp., 3-unit heat interchange system supplying make-up to the system in proportion to use of the old plant with a maximum of 40,000 lb. per hr. of steam. The heat interchange system consists of the following three units: steam-to-steam reheater having 215 sq. ft. of tube surface made up of ¾-in. O.D. chrome vanadium steel tubes 11 ft. long; 744 sq. ft. horizontal evaporator having 1 in. O.D. arsenical copper coils; 176-sq. ft. coil drain cooler having ⅝ in. O.D. arsenical copper tubes 10 ft. long.

Northern Equipment Company, 1, Copes CRI water pressure reducing valve for releasing 400 lb. per sq. in. condensate from the above system to the deaerators.

Manning Maxwell & Moore, Inc., 1, turbine room crane, 100 t. main hoist and 15 t. auxiliary hoist. Span 57 ft. 9½ in.; lift main hook 65 ft., auxiliary hook 70 ft.; speed main hook 6 ft. per min.; auxiliary hook 40 ft. per min. Motors 440-v., 3-phase, 60-cycle, General Electric type M.T.C.; main hoist 50 hp., 565 r.p.m.; auxiliary hoist 40 hp., 840 r.p.m.; trolley 30 hp., 845 r.p.m.; bridge 50 hp., 565 r.p.m.

Westinghouse Elec. & Mfg. Co., 1, ten circuit 2500-v. switching structure of the steel cubicle type.

Westinghouse Elec. & Mfg. Co., 1, two-panel control and metering switchboard. Westinghouse Elec. & Mfg. Co., 1, 480-v. switching structure.

General Electric Co., 12, single phase, 13,800-v., 300 amp. 3 per cent reactors.

General Electric Co., 2, three-phase, 2500-v., 800 amp., 5 per cent reactors.

Westinghouse Elec. & Mfg. Co., 4, three-phase, 13,800-v. lightning arresters, Autovalve type.

General Electric Co., 1, signal system of Selsyn type, consisting of one transmitting station and three receiving stations.

CIRCULATING WATER SYSTEM

U. S. Pipe & Fnd. Co., 60, 48, 36, and 30 in. cast iron B. & S. and flanged pipe and fittings added to the present system.

Ludlow Valve Mfg. Co., 4, 60 in.; 2, 36 in. and 4, 30 in. C. I. flanged gate valves with Limitorque Control operated by Westinghouse motors.

BOILER ROOM EQUIPMENT

Babcock & Wilcox Co., 1, steam generating unit for 400 lb. w. p. and 250 deg. F. superheat. Normal capacity 150,000 lb. per hr. Four hour maximum capacity 180,000 lb. per hr. Boiler heating surface 16,267 sq. ft.; interdeck superheater surface 5704 sq. ft.; return bend type economizer surface 1843 sq. ft.; Thermix type air preheater surface 19,500 sq. ft.; furnace volume 10,900 sq. ft.; B.t.u. per cu. ft. at maximum rating 23,800 per cu. ft. of furnace volume.

Diamond Power Specialty Corp., Soot Blowers.

Babcock & Wilcox Co. furnace of slag tap design with 1955 sq. ft. of water cooled side walls and bottom.

Babcock & Wilcox Co., 2, table type B pulverizers, capacity of each sufficient for operating boiler at 120,000 lb. of steam per hour. Operated by General Electric squirrel cage 100 hp. 2300 v. 720 r.p.m. constant speed motors.

Babcock & Wilcox Co., 2, drag type feeders with General Electric 2 hp. shunt wound, 250-v. d.c. motors, speed control from 500 to 2000 r.p.m.

Babcock & Wilcox Co., 2, exhausters driven by General Electric squirrel cage 60 hp. 2300-v. 1800 r.p.m. constant speed motors.

Babcock & Wilcox Co., 4, cross tube forced draft burners.

Richardson Scale Co., 2, automatic coal scales. Capacity 300 lb. per discharge; motor drive, 115-v., single phase.

Green Fuel Economizer Co., 1, No. 9¾ S.A. double inlet single width, full housed induced draft fan with two motor drive consisting of a 250 hp. General Electric, 2300-v. slip ring motor, speed varying from 225 to 450 r.p.m., and a 75-hp. General Electric 2300-v. motor, speed varying from 150 to 300 r.p.m., each equipped with 31 point speed control.

Green Fuel Economizer Co., 1, No. 52 R.B. double inlet full housed forced draft fan with two motor drive consisting of a 150-hp. General Electric 2300-v. slip ring motor, speed varying from 600 to 1200 r.p.m. and a 75-hp. General Electric 2300-v. slip ring motor, speed varying from 450 to 900 r.p.m. Each equipped with 31 point speed control.

Bailey Meter Co., automatic combustion control, including control panel, steam and feed water meter, draft gauges, temperature and pressure recording instruments.

DeLaval Steam Turbine Co., 2 2-stg. make-up pumps, 80 g.p.m. capacity, 480-ft. total head, 230-ft. positive suction head, and 250-ft. pumping head, driven by 15-hp. Westinghouse Class I line start, 440-v. 1750-r.p.m. motors.

DeLaval Steam Turbine Co., 1, 4-stg. motor-driven boiler feed pump, 400 g.p.m. capacity, discharge head 1190 ft. or 515 lb. per sq. in. Driven by 200-hp. Westinghouse Class I line start, 2300-v. 3500-r.p.m. motor.

DeLaval Steam Turbine Co., 1, 4-stg. steam turbine driven boiler feed pump, 400 g.p.m. capacity, discharge head 1190 ft. or 515 lb. per sq. in., driven by 175-hp. DeLaval turbine.

Schutte & Koerting Co., 2, 8 by 12 in. pressure reducing valves, capacity 150,000 lb. an hr., with Helpbringer pressure control and thermostatic temperature regulation.

Schutte & Koerting Co., 2, 12-in. surface absorption type desuperheaters; capacity 150,000 lb. an hr. each.

COAL HANDLING EQUIPMENT

Stearns Conveyor Co. coal handling system, having a capacity of 200 t. of coal per hr. and consisting of the following: Automatic dunlex reciprocating feeder driven by .10-hp. 1200-r.p.m. Westinghouse 440-v. motor.

410 ft. of 30-in. wide troughing belt conveyor for transferring coal from track hoppers to crusher house, driven by 15-hp. Westinghouse 440-v. 1200-r.p.m. motor.

Dings Magnetic Separator Co., pulley used in connection with this conveyor.

American Pulverizer Co., 1, No. 30 S ring crusher, having a capacity of 150 t. per hr. Driven by 50-hp. Westinghouse 2300-v. 600-r.p.m. motor.

Charleroi Iron Works, automatic coal sampler.

Automatic self-propelled, self-reversing tripper for use over the bunkers.

610 ft. of 24-in. wide troughing belt conveyor for transferring coal from crusher house to head house, driven by 20-hp. Westinghouse 440-v. 1200-r.p.m. motor.

720 ft. of 24-in. wide troughing belt conveyor for transferring coal from head house to bunkers. Driven by 10-hp. Westinghouse 440-v. 1200-r.p.m. motor.

ASH HANDLING SYSTEM

Allen-Sherman-Hoff Co. ash sluicing system with two disintegrating chambers, soot and ash collecting system from economizer and air preheater and sluice-way.

Allen-Sherman-Hoff Co., 2, vertical centrifugal ash pumps, 1500 g.p.m. capacity, rated head 85 ft., each driven by a 100-hp. type C.S. Westinghouse 2300-v. 900-r.p.m. motor.

Allen-Sherman-Hoff Co., 1, 6750 cu. ft. elevated ash storage tank of cast iron plate with dewatering system, and 2, 8-in. Ashcolite discharge lines from ash pumps to tank.

DeLaval Steam Turbine Co., 1, two-stage sluice water pump, capacity 1600 g.p.m. rated head 375 ft. Driven by 200-hp. Westinghouse Class I line start, 2300-v. 1750-r.p.m. motor.

to the coal bunkers in front of the boilers. Bunker capacity of 230 t. is provided for each steam generating unit. The coal is ordinarily received in a condition not requiring crushing and is by-passed direct to conveyor for delivery to the bunkers. All coal is automatically sampled by a Charleroi sampler, the sample being automatically crushed and deposited in jars. Coal is purchased on a heating value basis. Spouts lead from these bunkers through weighing devices to feeders which automatically control the amount of coal to suit the load on the boiler. These feeders admit the coal to pulverizers, two of which are located in front of the boiler and each pulverizer is large enough to carry the boiler at a load up to 120,000 lb. per hr.

The boiler furnace walls are covered with Bailey blocks. The furnace is of the slag tap design, with water cooled bottom. Coal used is Southern Kansas coal, running 18 to 22 per cent ash with a fusion temperature which varies from 1900 to 2200 deg. F. Heating value of coal is 10,000 to 11,000 B.t.u. per lb. All ash will be withdrawn as molten slag into disintegrating chambers, and sluiced to a central point, then pumped to an outside overhead receiving hopper located over the railroad track. The boiler is provided with economizer, air preheater, and automatically controlled forced and induced draft fans.

CONTRACTS LET FOR THE CONSTRUCTION OF THE WORK AND FOR FURNISHING EQUIPMENT

Steam generating unit, 150,000 lb./hr.	Babcock & Wilcox Co.	$ 284,800
Turbine Generator, 10,000 K.W.	Westinghouse Elec. & Mfg. Co.	183,550
Condenser, 15,000 sq.ft.	Elliott Co.	47,950
Cast iron pipe, 60 & 48 in.	U. S. Pipe & Fdy. Co.	23,100
Valves, 60, 36 & 30 in.	Ludlow Valve Mfg. Co.	24,604
Coal handling, 200 t. hr.	Stearns Conveyor Co.	48,668
Ash sluicing, 6,750 cu. ft. storage	Allen Sherman Hoff Co.	42,315
Concrete piping, 18,000 ft.	E. A. Whitney & Sons, Inc.	25,740
Closed heaters & evaporators	Foster Wheeler Corp.	17,160
Open heater & deaerator	Cochrane Corp.	10,100
Reducing valve & desuperheater, 300,000 lb./hr.	Schutte & Koerting Co.	8,271
Reactors & signal systems	General Electric Co.	6,676
Arresters & switchboard	Westinghouse Elec. & Mfg. Co.	21,724
Crane, 100 t.	Manning, Maxwell & Moore, Inc.	20,335
Exciter and m.g. set	Westinghouse Elec. & Mfg. Co.	4,823
Grading	Rand & Son	5,873
Buildings & foundations	Wyatt & Barcus	200,115
Structural steel	Kansas City St. Steel Co.	69,000
Wiring	Kelso Wagner Co.	69,400
Pumps	De Laval Steam Turbine Co.	10,870
Piping	Inter-State Htg. & Plumb. Co.	85,216
TOTAL		$1,210,290

Contracts let for the work and equipment totalled $1,210,290 as shown by the table. In addition to this, considerable work was done by the city's own force. All electrical connections to the present control board and switching station within the present building were done by the city; likewise, all steam connections to existing steam lines inside present buildings, and all circulating water lines were laid and connected by the city. This was done in order that the operating force would have entire control of these connections which could only be made at times suitable to the operating force.

Total installed cost is about $125.00 per kw. of generating capacity but this includes building space for an additional boiler to be installed shortly. Coal and ash handling equipment large enough for the ultimate plant and circulating water lines of sufficient size for the ultimate development were included.

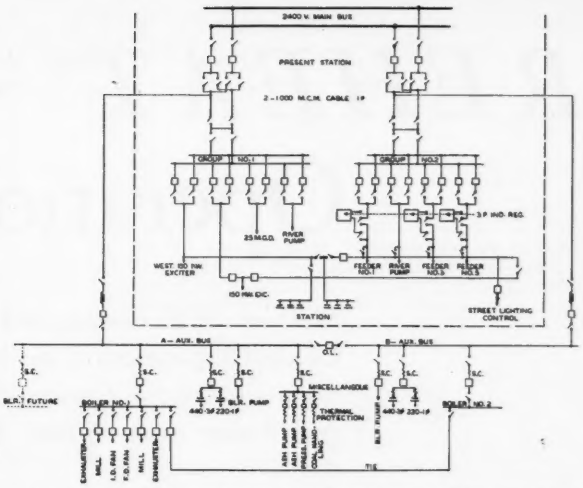


FIG. 6. WIRING DIAGRAM SHOWING THE 2300 V. AUXILIARY POWER SUPPLY FROM THE OLD PLANT

The preliminary report and plan of development, together with all detailed plans and specifications, as well as supervision of construction have been in charge of the Burns & McDonnell Engineering Co., of Kansas City, Mo.

Transmission Line for Hoover Dam

EFFECTIVENESS OF TRANSMISSION of electric power between Hoover Dam and the coastal area of California already is being demonstrated by a line that has been built from San Bernardino to the rim of Black Canyon and which is now delivering the energy that is playing so large a part in putting the four tunnels, 50 ft. in diameter, through the canyon walls.

This line, 222 mi. long, climbs over El Cajon Pass, 5500 ft. above the sea, and toils across the intervening desert waste. It now carries power to the Hoover dam site but, when the project is completed, will reverse the current and send it back to those populated areas that can consume it.

There are difficulties in the maintenance of such a line. Over the mountains, for example, it will be subjected to the strain of high winds and heavy ice loads. Under such circumstances supporting towers must be put close together. It has been found advisable to provide a substitute circuit to carry the load should the primary circuit fail. Already one occasion has arisen for using this second circuit. The supporting towers of this long transmission line are of the steel lattice mast type supporting a 34-ft. crossarm at a height of 52 ft. above the ground. Each of these structures weighs 2610 lb. The butt of each tower is set in concrete.

At present the line is now being operated at 88,000 v. It is insulated to carry 132,000 v. which will be its load after the dam is in and the current reversed.

At the dam the transmission line terminates at a substation on the rim of Black Canyon 815 ft. above the river and 1400 ft. west of the dam site. Here the current is transformed, made usable and distributed. This entire line and substation upon which beginning of the principal tasks at Black Canyon had to wait, was completed in 238 days after the first surveys were begun.

POWER PLANT ENGINEERING June 15 1932

REHEAT — Practice, Operation *and* Control

Methods of Reheating and Operation of Temperature Control Equipment Used in the Score of Reheat Stations Completed During the Past Five or Six Years and Using Gas, Steam and Combination Heaters

ASIDE FROM constructional and design requirements, reheat station problems differ from those of single expansion stations only in the need for control of the reheat temperature; provision for protection of the reheat elements from excessive temperatures and additional turbine governor protection against overspeeding.

Obviously, the exact requirements for a particular station will depend upon the individual design and arrangement of equipment. Some stations use a single boiler, others use two or more; some use convection, some radiant, some steam reheat elements while still others use a combination; some stations superimpose the high pressure turbines on low pressure equipment and have constant reheat pressure, others operate the high pressure turbines as part of a compound machine and have variable reheat pressure.[1]

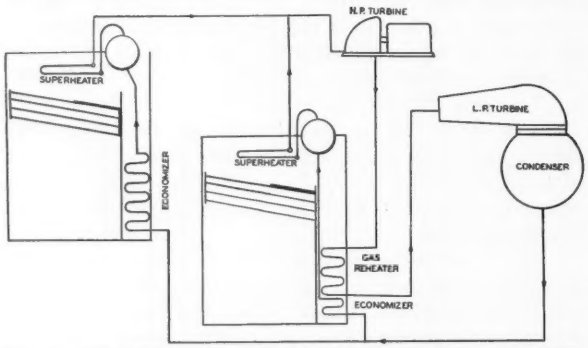


FIG. 1. ARRANGEMENT OF EQUIPMENT WHERE REHEAT TEMPERATURE IS CONTROLLED BY THE RATE OF FIRING OF A SEPARATE REHEAT BOILER

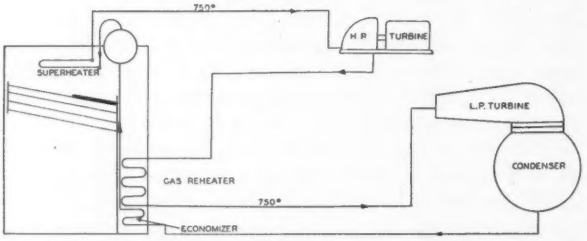


FIG. 2. WITH THIS SCHEME THE REHEAT TEMPERATURE VARIES WITH THE LOAD AND WITH THE TURBINE ARRANGEMENT

Sometimes radiant superheaters and convection reheaters or convection superheaters and radiant reheaters are used to maintain constant reheat temperature at all loads. The former is preferable for constant reheat pressure, the latter for variable reheat pressure. A combination superheater could be used with either arrangement if desired.

Gas to Steam Reheaters

In the first reheat stations[2] a combination of several standard and one or two reheat boilers per turbine unit were used. Increasing boiler sizes made it possible to reduce the number of boilers until at Deepwater, the latest station of this type, only one reheat and one standard boiler per turbine are used as shown by Fig. 1.

As its name implies, the standard boiler is a regular boiler designed to generate high pressure superheated steam. The reheat boiler has, in addition to the usual boiler and superheater surfaces, a secondary resuperheater or reheater which reheats the low pressure exhaust of the high pressure turbine to about the original temperature. The reheat boiler generates some high pressure superheated steam but the main function of the steam generating section is to screen the reheater coils and reduce the temperature of the gases of combustion to 1100 or 1200 deg. F. so that they do not give excessive reheat temperatures. Steam supply to the turbine in pounds per hour is regulated by the firing rate of the standard boiler, while the reheat temperature is controlled by the rate of firing of the reheat boiler. Operation of the two is interrelated to a certain extent but regulation can be and is accomplished by the usual combustion control systems.

Two reheat (and no standard) boilers were first installed at Edgar with the temperature of the reheated steam controlled by a movable baffle in the boiler supplemented at times by a desuperheater arrangement.[2] Lakeside cut the number of boilers to one per turbine unit and eliminated movable baffle control by taking advantage of the different characteristics of convection and radiant superheaters and reheaters.

Protection Against Excessive Gas Temperatures

It is apparent that the reheat coils might, with little or no steam flow, reach dangerous metal temperatures unless protected in some way. In the case of a sudden loss of load flow of steam through the reheater would be interrupted. To protect the boilers, the fuel feed is

[1] See Power Plant Engineering, July 1, 1931, P. 697.
[2] See Power Plant Engineering, Aug. 15, 1931, P. 840.

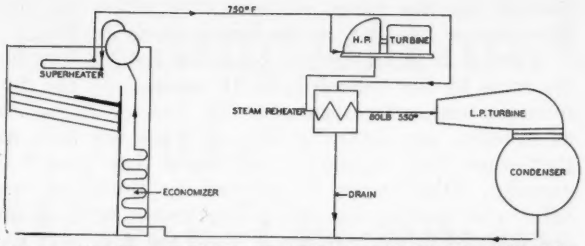


FIG. 3. WITH A DEAD END STEAM REHEATER THE REHEAT TEMPERATURE IS LIMITED TO THE SATURATION TEMPERATURE OF THE HIGH PRESSURE STEAM

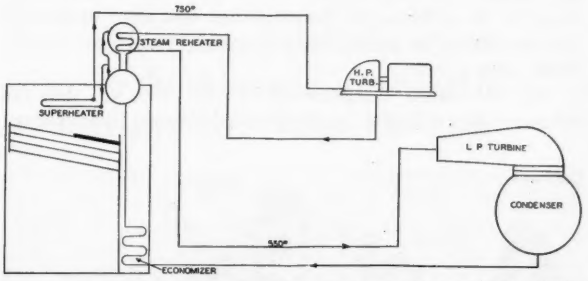


FIG. 4. THIS STEAM REHEATER NEEDS NO DRAIN PUMP BUT REQUIRES LOW PRESSURE PIPING TO AND FROM THE BOILER

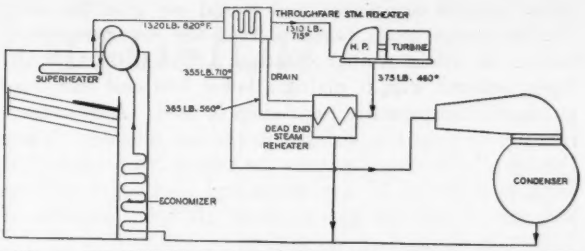


FIG. 5. BY USING TWO STEAM REHEATERS IN SERIES WITH A HIGH INITIAL SUPERHEAT, REHEAT TEMPERATURES IN EXCESS OF THE HIGH PRESSURE SATURATION TEMPERATURE CAN BE OBTAINED

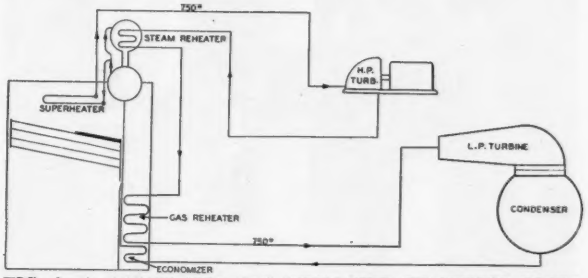


FIG. 6. A STEAM AND GAS REHEATER IN SERIES GIVES CONTROL OF TEMPERATURE AT ALL LOADS WITHOUT EXCESSIVE SURFACE IN THE CONVECTION GAS SECTION

stopped and in some stations air admission doors are opened, admitting cold air to the reheat section of the reheat boiler. This dilutes the hot gases of combustion and protects the reheat coils. Doors are operated by a motor under push button or automatic control. To take care of the excess high pressure steam without wasting it through the safety valves in these emergencies, a bypass and desuperheater arrangement is sometimes used. This will be discussed in greater detail later.

Steam to Steam Reheaters

After several reheat installations had been in service for some time the all steam reheater was introduced, the first installations having the reheaters at the turbine as at Crawford or, more recently, at River Rouge, as shown by Fig. 3. Another arrangement, Fig. 4, is to have the steam reheater directly over the boiler drum as at Concepcion. In either location the upper limit of the reheat temperature is the saturation temperature of the high pressure steam. The first location avoids the use of low pressure steam piping to and from the boiler; the second requires this piping but eliminates the drain pump and any degradation of heat head of the condensed steam drained from the heating coils. A third steam reheater arrangement, Fig. 5, as used at Deepwater (Tex.) uses two steam heaters in series. In this way it is possible to increase the reheat temperature considerably above the saturation temperature of the high pressure steam.[1]

Both the straight steam and straight convection gas reheaters are subject to certain disadvantages; the first because of the limited reheat temperature; the second because of the heater characteristic which cause the reheat temperature to drop as the load decreases. On base load stations this is not so important but stations designed for so called base load operation have, almost invariably, been subjected to variable load operation. Most of the recent high pressure stations have been designed specifically for variable load conditions.

Naturally a uniformly high reheat temperature is desirable at all loads. This can be obtained, as explained earlier, by a convection gas section with a separate reheat boiler as at Deepwater, or with a single boiler by installing sufficient heater surface to give the desired temperature with the comparatively cool gases at the minimum rating. This latter gives an undesirably high reheat temperature at high loads which can be taken care of as at Edgar by movable baffles in the reheat section; by gas bypass dampers; by a desuperheater or by some arrangement which would bypass a portion of the steam to be reheated around the heating section. The amount of steam which can be bypassed is limited, however, since a certain minimum velocity is required through the reheater tubes at each rating to prevent excessive metal temperature.

Steam and Gas Reheaters in Series

Such an arrangement of single boiler with only a gas convection heater would, for low-load operation, require a large and expensive reheat surface with addi-

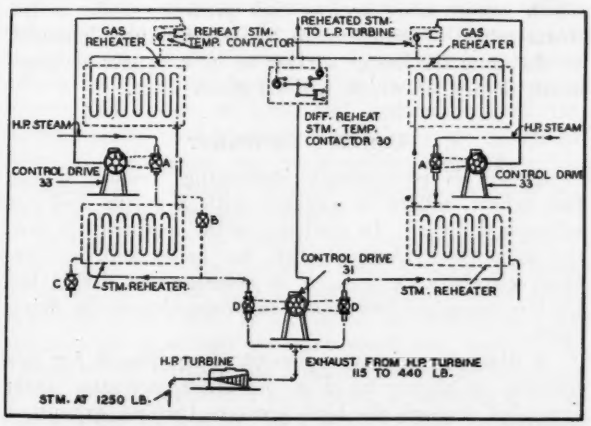


FIG. 7. DIAGRAMMATIC CONTROL FOR LOAD AND TEMPERATURE PROPORTIONING AS USED AT GILBERT STATION

tional control equipment and would not give the same flexible temperature regulation of the separate reheat boiler. In South Amboy, Station A and Gilbert, a different scheme, Fig. 6, giving a lower first cost and close automatic temperature regulation is used. A live steam reheater is placed in series with the gas reheater. When the drop in the load reduces the reheat temperature the exhaust is heated by live steam and then led to the gas reheater. Thus the gas reheater, though incapable of

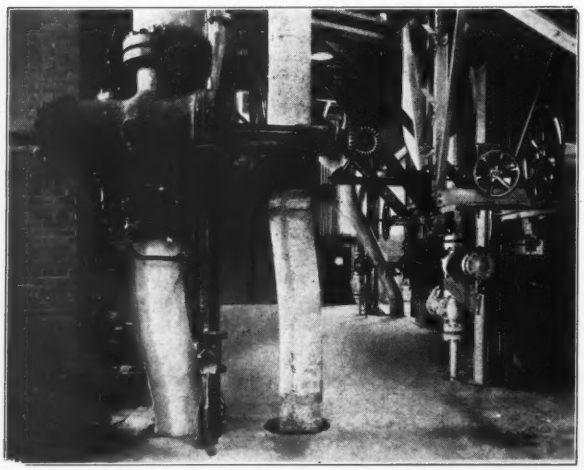


FIG. 8. PROPORTIONING VALVES INSTALLED. THESE ARE THE VALVES D OF FIG. 7

doing the whole job, is relieved of some of its work by the steam reheater and the exhaust steam temperature is maintained at about the figure for full load operation until the load drops off to about ¼ or ⅓ rating.

At Station A the steam reheater is cut out completely at loads in excess of 35,000 kw. (about 60 per cent). Beyond this point the reheat temperature is controlled by varying the proportion of high pressure steam between the standard and reheat boilers, an additional element of control not available at South Amboy where all the boilers have reheat sections and where the steam section is not cut out until maximum boiler rating. Both Station A and South Amboy were designed as variable load stations. Regulation of the temperature rise in the steam section may be accomplished automatically through a thermostatically controlled valve which admits more or less high pressure steam to the steam reheater according to the temperature demands, by changing the heater surface or by a bypass arrangement, details of which will be given later.

Control Equipment

Gilbert is particularly interesting because it has two reheat boilers in parallel with a steam and gas reheater for each. In addition to the temperature control as at South Amboy where one boiler and one turbine operate as a unit, it is necessary to divide the work between the two boilers in proportion to the firing rates.

A diagrammatic arrangement of equipment for this purpose is shown by Fig. 7. High pressure steam expanded through the high pressure turbine, exhausted at from 115 to 440 lb. is split between the two boiler units, passing first through the steam and then through the gas reheat sections after which the two lines join at the line to the low pressure turbine.

Control is in two steps. Steam is divided between the units by the control drive 31 actuated by the differential temperature contactor 30. The control valves as installed are shown by Fig. 8. They are built so that when both valves are half open they pass full capacity. Distribution is obtained by throttling one valve and opening the other. The motor drive which operates the valves is shown at about the middle of the right hand edge of Fig. 8 and in detail by Fig. 9. The ¼ hp. motor runs continuously and solenoid clutches are engaged to operate the drive sprocket as conditions require, the differential temperature contactor operating the control so as to maintain the same temperature rise from both sides.

If the steam temperature at the exit of the gas reheater drops below the desired minimum, temperature

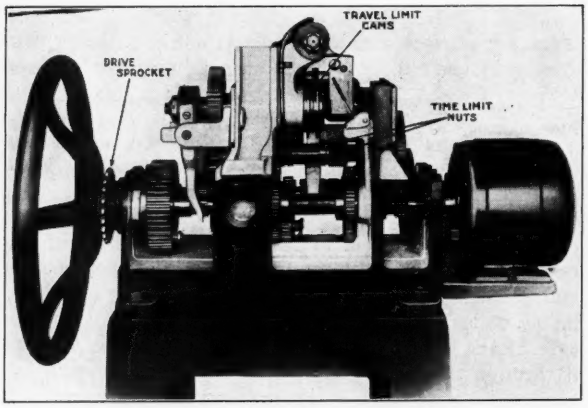


FIG. 9. MOTOR OPERATED DRIVE AND CONTROL EQUIPMENT. THIS IS MARKED 31 IN FIG. 7 AND CONTROLS THE VALVES SHOWN IN FIG. 8.

contactors at the exit of the gas reheat section actuate the control drives 33 admitting high pressure steam into the steam reheaters until the combined effect of both the steam and gas sections gives the desired temperature. As a matter of fact, the steam reheaters at Gilbert are seldom if ever required, the gas reheaters being sufficient to give the necessary final temperature at loads encountered. This latter equipment, that is one half of Fig. 7 exclusive of valves A and elements 30 and 31, is the same as that used to divide the temperature rise between the steam and gas sections in a single boiler unit as at South Amboy.

Bucket Conveyor Pulsations

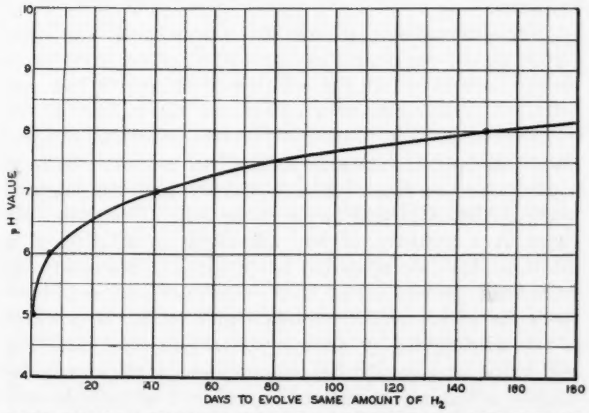
In the article on this subject on p. 378 of May 1st issue, the drive in Fig. 2 should be located between F and A sections, as pointed out in a letter from Mr. Lee, author of the article, who also offers to correspond with any who have conveyor troubles.

Three days, June 27th to 29th, will be important to members of the American Society of Heating and Ventilating Engineers as an extensive program of papers and reports will be discussed during the semi-annual meeting 1932 at Hotel Pfister, Milwaukee, Wisconsin.

Placing pH in Corrosion and Water Treatment

Corrosion Can Take Place in the Absence of Oxygen if the pH Value Is Low

By S. E. Tray *



CORROSION ACTIVITY IN THE ABSENCE OF OXYGEN IS A FUNCTION OF THE pH VALUE. Shipley & McHaffie made tests to show the corrosive properties of oxygen free water. Flasks with varying pH values were used. Evolution of hydrogen was taken as a measure of corrosion and the time required to evolve 25 c.c. measured. Results are plotted on the curve. After standing 2 yr. all flasks reached a pH value of 9.6.

ONE OF THE CHIEF REQUISITES of a steam generating station is a constant supply of pure water, pure in the sense that it should contain no scale-forming salts, exhibit no corrosive tendencies and be free from suspended matter and high concentrations of soluble salts. This type of water has become especially essential with the advent of higher pressures and temperatures, but unfortunately such water is not found in nature. It is therefore necessary to subject the natural raw waters available to such treatment as will produce the ideal type desired. Within the last few years the technique of feedwater treatment has undergone rapid changes and expansion until the present state of the art, while not yet an exact science, is nevertheless capable of definite control based on accurate knowledge of conditions within the boiler.

The familiar expression, "Don't make a chemical retort of your boiler" has been advanced for many years as the strongest argument against any form of internal treatment. Consideration of the action of boiler water under conditions of high temperature and pressure, however, will show that in spite of any efforts to prevent it, the boiler drum is among the most sensitive and delicate of chemical retorts. Even pure distilled water contains some soluble salts and in contact with the steel tubes of boilers and economizers it reacts chemically to such an extent that even at the present time the full importance of corrosion has not been realized.

The whole question of feedwater conditioning, the methods used for treatment and the equipment required, are so largely dependent on the nature of the raw water that a full understanding of the types of water usually encountered is desirable. In general, industrial waters fall into two classes, temporary hard and permanent hard water. The present accepted terminology is carbonate and non-carbonate hardness which more accurately describes the character of the water.

As a means of determining the constituents of the raw water a complete mineral analysis is essential. The interpretation of the analysis is then a matter of judgment and experience, but because of the wide controversies raised as to the method of reporting analysis, the Chemist's Subcommittee of the Prime Movers Committee of N. E. L. A. has recommended the ionic form as standard.[1] The mineral substances found in water are present predominantly as ions, rather than compounds. A condition of 98 per cent dissociation may be shown to exist in water containing dissolved solids under 2000 p.p.m. In addition, it is impossible to analyze water for compounds, as only the amounts of individual ions can be determined. Consequently any hypothetical combination is a matter of personal opinion, and variations in combinations of the same water may indicate widely varying characteristics.

Corrosion

Probably the greatest single cause for the failure of power plant equipment is that due to corrosion of material. There are many kinds of corrosion due to different agents, but among the most important is that due to the nature of the feedwater. This type of corrosion affects not only the feed lines and heaters but economizers and boilers as well, and, indirectly, even the turbine nozzles and blading. Accordingly, no system of feedwater treatment can be complete which does not recognize the existence of such corrosion or does not provide a means of combating it.

Without going too deeply into the theory of corrosion, it can be shown that pure water contains not only molecules of water H_2O but separated parts of these molecules called ions, H and OH. In pure water, the amounts of these ions are very small and, under conditions of equilibrium, the product of the concentrations of the H and OH ions is a constant, amounting at room temperature to a value of 1×10^{-14}. The importance

*Sargent & Lundy, Chicago, Ill. This article is part of a paper, Practical Essentials of Feedwater Treatment, read by the author before the Prime Movers Committee of Great Lakes Section of the N. E. L. A. in Chicago, April 14, 1932.

[1]Report of Prime Movers Committee, 1928-1929, Publication No. 289-114.

of this dissociation constant cannot be overestimated in any study of corrosion. Any increase in the concentration of either ion must cause a decrease in the concentration of the other ion if the product is to remain constant.

For convenience, a number representing the logarithm of the reciprocal of the hydrogen-ion concentration is used to define the relation of H and OH in any solution. This number is called the pH value. A pH value greater than 7 means that the solution contains more OH than H ions and is therefore alkaline, whereas a pH value less than 7 means that the solution contains more H than OH and is therefore acid. Hence the pH value is a measure of the alkalinity or acidity of a solution. Its determination has a specific sphere of usefulness in the control of boiler feedwater, since it indicates the active acidity or alkalinity of a water which is not discernible by ordinary titration methods. The pH value can easily be determined in the plant by simply matching colors with prepared standard solutions.

When iron is in contact with water, it replaces some of the hydrogen ions and goes into solution. The products of this chemical change are two: ferrous hydroxide, a soluble salt of iron; and hydrogen, not liberated as a gas, but existing as a film on the surface of the metal. As the iron dissolves in the water, the concentration of the ferrous hydroxide increases. This compound ionizes to such an extent that the pH value of a saturated solution of ferrous hydroxide is 9.6, and at this pH value an effect similar to back pressure prevents the formation of more ionic iron and thus prevents the solution of metallic iron. If, instead of permitting the dissolution of iron to build up the pH value by the formation of ferrous hydroxide, the concentration of the hydroxyl-ion is increased by some other means until the pH of the boiler feed is 9.6, the same result is obtained; namely, prevention of the solution of iron.

When oxygen is simultaneously present, it unites with ferrous hydroxide to form ferric hydroxide and with hydrogen to form water. Ferric hydroxide is red, like ordinary iron rust, and very insoluble. The removal of the two products formed when iron goes into solution thus eliminates all dissolved iron from solution and the water is free to attack the metal once more. It must be emphasized that in this manner the dissolved oxygen accelerates the dissolution of iron. Therefore, if there is an unlimited supply of oxygen, then there is no limit to the amount of iron that can be corroded by a given amount of water.

pH Is the Velocity Factor of Corrosion

Where a large volume of oxygen-free water continually flows over the metal, as in an economizer, the hydrogen formed may be carried away in solution to such an extent as to maintain a rapid rate of corrosion. As would be expected, at the higher pH values, gas evolution is slow, but is proportional to the hydrogen-ion concentration. Corrosion in all cases can therefore be said to comprise a velocity or intensity factor, and a quantity factor.[2] The velocity factor is a function of the pH value of water, since the rate of dissolution of iron is dependent on this. The quantity factor is a function of the available dissolved oxygen. From the standpoint of elimination of corrosion, the ideal would be zero intensity and quantity factors, but as this is an impossibility in practice, it is necessary to establish tolerances for both factors that provide sufficient limitation to render any corrosive action negligible in amount.

The pH value of the boiler feed can be easily maintained at approximately 9.5. In low make-up plants, this can probably best be accomplished by recirculating a portion of the water from the boiler drum, which will normally have a pH of about 11.0, back to the suction of the boiler feed pump. Experiments have shown that given a boiler feed with a pH value of 7.0 at the feed pump, only about 500 lb. per hr. of boiler water will be required to give a pH of 9.5 with a total steam production of 300,000 lb. per hr. Normal variations in loads will not affect this value, since the load would have to increase ten times to reduce the pH from 9.5 to 8.5 with a constant amount of recirculation. In the case of higher make-up plants, the pH value can be increased by the addition of caustic soda at some point in the feedwater cycle. More accurate control is necessary under these conditions, however, in order to avoid increasing the boiler water alkalinity beyond the danger limit.

Importance of Oxygen May Be Overestimated

With the maintenance of a high pH value in the boiler feed, the effect of dissolved oxygen is greatly reduced. Unfortunately there is not enough available information on this phase of corrosion, since it has been considered too recently. The results obtained in one plant, however, may indicate the trend which may be expected. For three years, this plant has maintained a pH of 9.5 at the boiler feed pump with an average oxygen concentration of 0.5 c.c. per liter and it reports no trace of corrosion in steel tube economizers. This value of oxygen is somewhat higher than that usually allowed in central stations but it can be maintained without recourse to deaerators or chemical means, especially where heaters are properly vented. It is quite evident that too much emphasis has been placed on the complete removal of oxygen without due regard for the pH value of the boiler feed.

There has been considerable discussion on the use of ferrous hydroxide for the elimination of oxygen in high pressure boilers, but since the part that this chemical plays in raising the pH value has been demonstrated, it throws an entirely new light on what actually happens. Unfortunately, no pH studies have been made in connection with most of the work with ferrous hydroxide, so that it is impossible to state the condition of the water before treatment. Undoubtedly the water was of low alkalinity, and as such would have caused considerable corrosion even in the complete absence of oxygen.

Foaming and Priming

In 1928, Mumford[3] made an extensive series of experiments on the high pressure boilers of the New York Steam Corp. and came to the conclusion that the hydroxyl-ion concentration played the chief role in the production of wet steam. He found a value for this concentration above which the production of dry steam was practically impossible. For the type of boilers in question, Mumford places this critical value of the hy-

[2]Some Fundamental Considerations of Corrosion—R. E. Hall and A. R. Mumford. Presented at 38th Meeting of A. S. H. V. E.

[3]A. R. Mumford—Transactions of A. S. M. E., Vol. 51—p. 363.

droxyl-ion at about 250 p.p.m. but points out that this critical value is a function of boiler design.

Within the past year, the effect of the hydroxyl-ion concentration on carry-over has been well demonstrated at one of the stations in the Chicago district. Phosphate was being used for the prevention of caustic embrittlement in connection with some carry-over from the evaporators. Tri-sodium phosphate was introduced into the condenser hotwell, and as a solution of this salt has a pH value of about 12.0 the pH of the boiler feed was raised sufficiently to prevent any corrosion in the economizers. In the boiler drum, the calcium from the evaporator carry-over removed the phosphate with the production of an equivalent amount of sodium carbonate. This immediately hydrolyzed under boiler temperature to caustic soda and carbon dioxide, the latter passing off with the steam.

Concentration of the caustic soon increased beyond the critical value for the boilers in question, and the resulting carry-over soon reduced the capacity of the turbine more than 15 per cent. An analysis of the blade deposits further confirmed the part played by the hydroxyl-ion. This showed 60 per cent caustic soda anhydride, 15 per cent carbonates, and 20 per cent silica. The material was 80 per cent soluble and was easily removed by washing with wet steam, which, however, did not remove the underlying cause of the carry-over. This is an excellent illustration of the careful control necessary for correct feedwater conditioning, in order that the introduction of one chemical such as is required for the prevention of caustic embrittlement will not result in an undesirable effect on some other phase of the treatment.

Ultimate Aim of Feedwater Treatment

The ultimate aim of feedwater treatment, then, is the production of a water free from scale-forming elements, exhibiting no corrosive tendencies, and having no suspended matter or high concentrations of soluble salts. The relation of the various phases of treatment must be considered when it is outlined, but once established, correct treatment can be easily maintained by normally intelligent operators without recourse to expert chemical knowledge except in unusual cases. There should be frequent and regular routine analyses, which can be made with simple laboratory equipment. Daily records should be kept in order to provide the station with a complete history of its water and to ascertain more readily any change which may take place from time to time. The results of careful control of the feedwater will be apparent in reduced outages of boilers, economizers, and turbines; in overall station efficiency; and in decreased maintenance and repair costs.

The problem is not the same for all stations. Variation in equipment in operating conditions, and especially in the character of the raw water used make each plant an individual problem. The underlying principles are nevertheless the same, and by assimilating the combined experience of many stations, the ultimate aim may be achieved. Much is still to be learned, as continued research in this field will show and only by the application of the results of such research can the future high pressure boilers hope to be successfully operated.

Cast iron can be made flexible by addition of a small percentage of nickel.

Fuel Oils, Qualities and Storage

By Charles A. Whitney*

STATEMENT in an article on Automatic Burning of Fuel Oil by C. C. Custer that "Oils are dangerous in proportion to their so-called flash point" seems to call for some comment. In the oil burner industry "Automatic burner" means fully automatic or, under the Underwriters' definition, an installation "Where a competent attendant is not constantly on duty in the room where the oil is burned."

Flash point of a product is defined as the temperature to which it must be heated in order to give off sufficient vapor to form an inflammable mixture with air. This temperature varies with the test apparatus and procedure, consequently both must be specified when the flash point of an oil is stated. The Pensky Martens closed cup tester is specified for fuel oils in the Commercial Standard Specifications of the U. S. Bureau of Standards.

Flash Point Allowable

When low flash point oils are used, certain precautions are necessary as far as storage and installation are concerned, to prevent the accumulation of vapors inside the building. One of the best ways to accomplish this is to follow the rules of the National Board of Fire Underwriters. If piping is installed so that no leaks can occur and tanks are properly vented, adequate protection is afforded.

Flash point is related more to the reliability of operation of a burner than to hazard. Low flash point oils are essential for some types of burners to secure dependable ignition. To supply such burners with oil flashing at above 150 deg. F., closed cup, would be contributing to a hazardous condition rather than eliminating one. For industrial installations using heavy oil, the oil is frequently preheated at the burner to temperatures considerably above the flash point. Operating difficulties may be encountered when heavy oils are heated to an excessively high temperature, since vapors may be created which will cause oil pumps to vapor-bind and may also cause the flame to fluctuate or even go out completely.

Through a lack of understanding of these conditions, several cases have occurred where local officials have specified a minimum flash point such as 150 deg. F. but later have approved for installation oil burners which could be operated only with oils having a lower flash point. As the industry has advanced, numerous cases have occurred of new regulations or change in existing ones after better appreciation of these conditions. A minimum flash point of 100 deg. F. Pensky Martens closed cup tester is allowed by the National Board of Fire Underwriters with 110 deg. F. as the minimum flash for commercial standard oils.

Gravity and Oil Grading

As to gravity, this is not a true indication of the burning quality of an oil, since one oil of a given gravity may flow readily and light with comparative ease, while another of the same gravity may be more viscous, have a higher or lower flash point and, in general, have properties quite different from the first.

*Technical Secretary, American Oil Burner Association.

In January, 1929, after a long series of exhaustive investigations by the American Oil Burner Association, American Society for Testing Materials, the American Petroleum Institute, and the Underwriters' Laboratories, specifications were developed for six grades of domestic and industrial fuel oils and approved at a general conference of refiners, distributors and consumers of fuel oil, manufacturers of oil burners and other general interests. The following outline of these requirements has been taken from the Department of Commerce publication entitled Commercial Standards CS 12-29:

Domestic Fuel Oils

Grade	Flash Pt. Deg. F Min.*	Max.	Water and Sediment Max. %	Pour** Point Max. Deg. F.	Distillation Points, Max. Deg. F. 10%	90%	End Pt.	Viscosity Max.
No. 1 Light	110	165	0.05	15	420		600	
No. 2 Med.	125	190	0.05	15	440	620		
No. 3 H'vy.	150	200	0.10	15	460	675		Saybolt Universal 100°F, 55 sec.

* Lower than shown may be used if legal
** Lower or higher may be specified when required by conditions; but never less than 0° F.

Industrial Fuel Oils

Grade	Flash Pt.* Min. Deg.F.	Water and Sediment Max. %	Viscosity Max.
No. 4 Light	150	1.0	Saybolt Universal 100°F, 125 sec.
No. 5 Med.	150	1.0	Saybolt Furol 122°F, 100 sec.
No. 6 H'vy.	150	2.0**	Saybolt Furol 122° F, 300 sec.

* When required, as for burners with automatic ignition, maximum flash temperature may be specified but never less than 250 deg. F.
** Maximum sediment 0.25 per cent
Pour point may be specified when required by conditions but never less than 15 deg. F.

In an endeavor to safeguard property, early ordinances sometimes required such restrictive measures as a minimum flash point of 135 to 150 deg. F.; tanks to be placed below the burner with a minimum cover of 4 ft.; inside tanks prohibited and gravity feed limited. With improvement in oil burner design and manufacture many of the restrictive measures were unnecessary. The National Board of Fire Underwriters rules have passed through a number of revisions based on records, the last revision being in January, 1931.

Among others, these revisions permit 275-gal. gravity feed tanks; inside, unenclosed storage in 275-gal. units up to 550 gal.; increase in minimum size of vent pipe to 1¼ in. and elimination of screens from vent pipes. Because of this, many cities now consider these regulations as standard and embody them into ordinances.

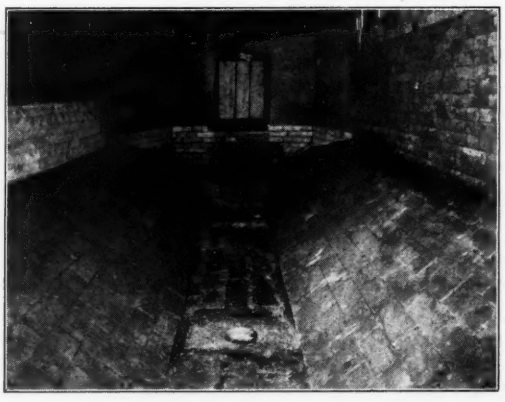
Nothing is now to be gained in the purchase of oil by installing a large tank, as many oil companies will contract on a "keep full" basis with no differential against the small tank. True, a few cities, mainly on the Pacific Coast, require tanks to be installed below the burner but many cities, as previously stated, are replacing the formerly restrictive requirements with the more reasonable rules of the National Board of Fire Underwriters.

When light oils are stored, fill lines are comparatively small but seldom under 2 in. and, in the case of long lines, the size is increased to permit a rapid flow of oil. Fill pipes as large as 4 to 8 in. are usually found on industrial installations where heavy oil is burned. Minimum size of vent is 1¼ in. although many cities permit ¾ in. under the old requirements; screens in vent pipes have been found to be objectionable in that they serve no purpose for which they were intended but clog with dirt and prevent escape of vapors.

Any one contemplating the installation of an oil burner should first familiarize himself with all city and state regulations, then with the rules of the insurance rating organization having jurisdiction. Where there are no local or state laws on the subject the wisest course is to follow the rules recommended by the National Board of Fire Underwriters.

New Boiler at Chappel Bros. Packing Plant

SEVERAL NEW FEATURES have been added to the original design of one of the new type S & G steam generators just installed in the packing plant of Chappel Bros., Inc., at Rockford, Illinois. This company makes the dog food, Ken-L-Ration, which is cooked in cans under steam pressure. The power load carried ranges from 5000 to 35,000 lb. per hr. A full description of this new type boiler designed by K. C. Schmidt, of the Freeman Boiler & Eng. Co., Chicago, was published on page 160 of the Feb. 15, 1932 issue.



VIEW OF NOVEL ASH-REMOVAL EQUIPMENT WHERE STEAM-POWERED SUCTION DRAWS OFF THE FINE ASH OF THE PULVERIZED COAL

A novel feature of the Chappel installation is a perforated, semi-V-shaped floor design through which ashes may be drawn out by steam-operated suction pipes without interfering with the operation of the boiler. Another innovation is the two new Vulcomatic soot blowers with push button control, used for the first time in a commercial plant.

Heating surface of the new generator is about 4000 sq. ft., about 40 per cent being radiant and 60 per cent convection surface. The two outside rows of tubes have been extended about 8 ft. to make a water-cooled furnace about 8 by 12 ft. in cross section. Plibrico jointless firebrick is used in all furnace walls. The pulverizer is a dual-drive Strong-Scott Unipulvo, with a maximum capacity of about 3500 lb. of coal per hr. At present West Kentucky screenings are being burned. The generator replaces two hand-fired Stirling boilers with an estimated reduction in operating costs of 35 per cent.

Power Utilization

Return Line Corrosion

By Edward P. Schinman*

Corrosion from Insufficient Pitch

Oxygen Is Chief Cause. Remedy Is Removal of Oxygen and Keeping Pipes Free of Moisture

WITHOUT going into lengthy discussion of the theory of return line corrosion or a consideration of the chemical reactions involved, it can be stated that the following facts have been definitely established.

1. Products of corrosion always contain oxygen.
2. Oxygen present in solution is essential for appreciable corrosion to take place in normal water, the amount of corrosion being almost directly proportional to the oxygen concentration.
3. Oxygen corrosion is accelerated in acid (low pH) and is retarded in alkaline (high pH) solutions.
4. Under ordinary conditions, iron will not corrode in the absence of moisture.

Since in most natural water supplies, oxygen is the principal element which causes corrosion, the problem of preventing corrosion resolves itself into preventing the oxygen in solution from coming in contact with the metal.

Deaeration of Feedwater

In order to prevent the presence of oxygen in the steam and subsequently in the condensate it is necessary to deaerate all the feedwater completely. For the average boiler plant, this is accomplished by properly operating ordinary open or mixing feedwater heaters of ample size which are well vented to the atmosphere, the feedwater stream (makeup plus returns) being broken up into small droplets falling through the steam space. By heating the water to the boiling point corresponding to the pressure at which the heater operates and venting the heater liberally, the dissolved gases driven out of the water by the high temperature escape freely to the atmosphere.

This method of removing the dissolved oxygen and other gases from the water is based on the fact that the solubility of gases in water decreases with an increase in temperature and at the boiling point is zero. As the pressure in the heater may be higher than atmospheric, temperature of the water in the heater must be maintained at the boiling point of water at this higher pressure, as given in the following table.

*Chemical Engineer

WATER HEATER TEMPERATURE FOR VARIOUS PRESSURES

Pressure, Lb. Gage	Temperature, deg. F.	Pressure, Lb. Gage	Temperature, deg. F.
0	212.0		
1	215.3	6	229.8
2	218.5	7	232.4
3	221.5	8	234.9
4	224.4	9	237.1
5	227.2	10	239.4

If the exhaust steam is insufficient throughout the 24 hr. of the day to keep the water in the heater at the boiling point corresponding to the heater pressure, live steam must be introduced into the heater to keep the temperature up continuously. This involves no waste of heat because the heat added to the water by the live steam is returned to the boiler in the form of hotter feedwater.

Live Steam Heating

Figure 1 illustrates the introduction of live steam to the heater by a perforated pipe, installed directly above the water surface to distribute steam uniformly

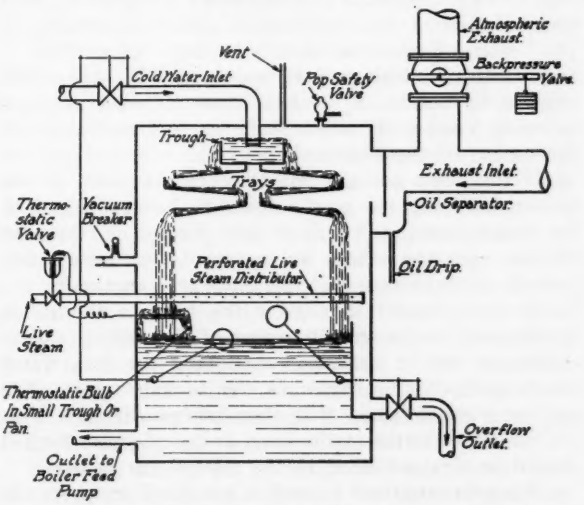


FIG. 1. LIVE STEAM DISTRIBUTION IN OPEN HEATER

over the horizontal area of the heater, avoiding water hammer and making contact with all the falling water droplets, so that all live steam is condensed before it can escape through the vent.

In the live steam line, a thermostatic valve is installed, the bulb being located in a small pan or trough at the bottom of the steam space directly over the water surface. This valve will open whenever the water falling from the trays into this small trough is below the boiling point and will close when the boiling point is reached, thus preventing the use of excessive live steam or waste through the heater vent. The purpose of the small trough in which the thermostatic bulb is located is to make the thermostatic valve respond quickly to rapid temperature changes in the falling droplets rather than to slower temperature changes of the water in the storage space below. This small trough should be provided with an overflow pipe outlet connected to the bottom of the trough to keep the water circulating through it.

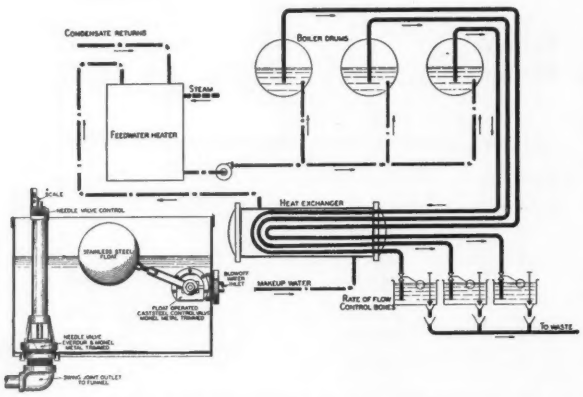


FIG. 2. HEAT RECLAIMING FROM CONTINUOUS BLOWOFF, COMBINED WITH DEAERATING HEATER. INSERT, DETAIL OF FLOW-CONTROL BOX

Gases Must Be Vented

Proper venting of the heater is especially important. There should be at least two vents, one at the top, the other directly below the main trays. For long or large heaters two top vents are necessary to prevent local accumulation of non-condensable gases in portions of the heater. Each vent should be installed so that it rises vertically, with no portions that incline downward or even lie horizontal, because these may act as traps to collect condensate which seals the vent and prevents the escape of the liberated gases.

If the vents are too large for the pressure in the heater, allowing too much steam to be discharged to the atmosphere, and valves are placed on them to throttle the flow, these valves should be tested frequently to make sure that the vents are functioning.

If it is desired to recover the heat in the steam which may escape from the vent of the heater, a vent condenser can be installed, employing the cold water on its path to the heater as the cooling water. The non-condensable gases will then escape directly from the condenser to the atmosphere, and condensate formed should be drained back to the top of the heater.

When intermittent blowoff is practiced or where the load is increased suddenly, care must be taken that the increased flow through the heater does not momentarily overload the deaerating capacity of the heater. Unless the load on the heater is carefully watched, some incompletely deaerated water may pass into the boiler and, if this occurs, serious corrosion may be experienced. Recently, two specific cases came to the writer's attention. To overcome this difficulty the installation of a continuous blowoff system was recommended. Following the installation of this continuous blowoff system, which also recovered the available heat from the blowoff, Fig. 2, oxygen tests on the effluent of the heater showed continuous satisfactory operation.

After passing through the heater constructed and operated as above, the feedwater will contain but small amounts of oxygen, consequently the steam and the condensate produced will not tend to be corrosive.

That the above method of keeping the steam free of oxygen is satisfactory was demonstrated quite vividly a short time ago at a distilled water ice plant. Condensate was so contaminated by corrosion of the pipe lines that the ice manufactured from it had a decided reddish color, hence ice was unsatisfactory. As investigation showed that the plant had no open heater, the plant owners were advised to install one. After its installation, the steam and the resulting condensate were practically oxygen free, no more corrosion was experienced and the ice was entirely satisfactory.

After oxygen-free steam has been produced, care must be taken to prevent oxygen from getting into the condensate by infiltration, hence all joints and valves must be maintained air tight. In making up pipe joints a suitable lubricant should be used. The usual red lead and glycerine mixture is good but it can be made to produce a much tighter joint by the addition of about 60 per cent zinc dust, fine enough to pass a 200-mesh sieve. Tendency is growing toward the use of welding to insure air-tightness of return lines, many supply houses now offering special fittings developed for this type of work.

Large Size, Steep Pitch and Proper Trapping Essential

Return lines should be large, well insulated and pitched downward in the direction of flow as steeply as possible, with no rising or long horizontal portions, pockets or bends. Condensate must flow freely and rapidly so that it remains in contact with the piping as short a time as possible. Obviously, if the water is in contact with the metal as short a time as practical, the possibility of corrosion is minimized because corrosion, like other chemical reactions, requires time for its completion.

When return lines drain quickly and properly, they become dry soon after the steam has been shut off. No corrosion can take place, since the time of contact has been short and the presence of moisture is essential for corrosion to occur.

In this connection, steam shut off valves should be kept tight when closed as, if these valves leak even slightly when shut off, some steam vapor enters the system, will absorb oxygen by contact with the air which enters through the radiator air valves or the return line and this mixture will cause corrosion.

Return lines from equipment, such as dryers and heaters, which generally operate at higher pressures than the heating system, should never be connected into

the heating system returns, since the discharge from such equipment may back up into the heating system return line when the latter is not in use. In such instances, the mixture of steam vapor which condenses and air would cause corrosion.

Properly pitching and trapping the return lines and making them large enough so that the condensate drains freely and rapidly cannot be emphasized too strongly. It is no exaggeration to say that this is the most important factor in the design of return lines.

As a striking example of this necessity, an official of one of the largest railroad terminals in the country, at a recent meeting of the American Society of Heating and Ventilating Engineers in New York City, said that he took down pipes close to the steam main and found no corrosion. Neither was there corrosion in the drip lines from these steam mains, the drip lines being submerged at all times. This is what would ordinarily be expected because the presence of oxygen and moisture is essential for corrosion and the steam produced from deaerated feedwater contained no appreciable quantities of oxygen.

He examined returns from radiators and found that, where there were horizontal pipes which were small or insufficiently pitched or where steam fitters had neglected to ream out the burrs on the edges of the pipe entering the fittings, there was serious corrosion. In fact, some of the pipe which failed was only 2 yr. old.

When making up pipe lines, the use of dissimilar metals in contact should be avoided because corrosion is frequently accelerated at the points of contact of the two metals. If two dissimilar metals are to be connected, an insulating joint should be used.

Protecting Return Lines By Feeding Oil

Unless contaminated by leakage of hard water, condensate is free from incrusting salts so that no deposits which would tend to protect return lines against corrosion will tend to form. When, however, condensate from the exhaust of reciprocating engines is used, a film of oily products may be formed in the lines, which protects the pipe.

In several cases on record, such return lines have been giving good service for more than 20 yr. without corrosion, apparently because of the protective film of oil. When the source of steam is changed from the exhaust of reciprocating engines to steam coming directly from the boiler or from the exhaust of turbines, the oil film, which has previously been formed, gradually disappears and corrosion may then be experienced.

In view of the above, many large buildings have resorted to the feeding of oil into the exhaust steam lines with an engine lubricator. Varying degrees of success have been reported but more data on the amounts and kind of oil necessary to obtain the desired results are needed before any general conclusions can be formed. This method of preventing corrosion in existing return lines seems, however, promising and its use is rapidly increasing, especially in buildings or plants which are experiencing difficulty because of existing conditions.

It must be noted that when condensate containing this oil is to be used for boiler feed, the oil should be removed by coagulation and filtration.

To prevent external corrosion, all return lines should be laid in a dry place. If they are laid in a cinder fill, sufficient lime mortar must be mixed with the fill to neutralize any acidity present and keep the pipe from contact with the cinder. In places where the pipe passes through concrete, it should be well insulated in order to prevent possible electrolysis, as moist concrete is a good conductor.

Summarizing, to overcome or prevent corrosion in return lines, the following precautions should be taken:

1. The feedwater, returns plus makeup, should be heated to the boiling point in a properly vented open heater to remove the oxygen.
2. The return lines must be made tight to prevent the infiltration of air.
3. The return lines should be large, pitched downward as steeply as possible and properly trapped. This is the most important single factor in the design of return systems.
4. All valves should shut off tight.
5. Return lines from equipment using steam at higher pressures should not be connected into the heating system returns.
6. The use of dissimilar metals in contact should be avoided.
7. A small amount of oil may be fed into the steam line by means of an engine lubricator to form a protective oily film in the pipe.

Bearing Temperature At High Speeds

ALTHOUGH CARRIED out as an investigation of automobile engine bearings, conditions as given by C. G. Williams in Engineering of London would seem to be related to all bearings which are used on high-speed machines. Cooling was by dispersion of heat to the crankcase air from the moving connecting rod end, also by flow of oil but this was so small that the heat carried away by the oil was determined to be almost negligible.

It was found that the bearing temperature increased with running speed more rapidly than the speed but increased with crankcase temperature almost directly, regardless of speed. With crankcase temperature constant, bearing temperature decreased steadily but quite slowly as oil flow was increased; it increased but slowly with increase of oil temperature at constant flow.

To embody the factors which influence bearing operation, Mr. Williams uses the expression: $ZN \div P$ to express the coefficient of friction, in which Z is viscosity in centipoises, N is revolutions per minute and P is the bearing pressure expressed in pounds per square inch on the projected area of the bearing. Viscosity was determined from oil temperature, the relation between the two for the oil used having been determined by viscosimeter tests. N was, of course, observed and P was calculated from journal dimensions. From an experiment it was determined that for the bearing tested values of $ZN \div P$ less than 100 resulted in breaking down of the oil film and rapid rise in the coefficient of friction. From other data, however, it was felt that, for the usual run of bearings, the breakdown would be at lower values, say around 30 for $ZN \div P$.

Studying the effects of crank case temperature and oil temperature on the value of the above expression, its value rose rapidly with decrease of crank case tem-

perature, due to increase of viscosity. For a given crank case temperature it varied inversely with speed but not in direct proportion, the rise of $ZN \div P$ increasing more rapidly as speed became less.

Reducing inlet oil temperature had little effect; reducing crankcase air temperature caused a pronounced rise in the coefficient of friction while reducing both temperatures caused a rise of $ZN \div P$ considerably larger than the sum of the individual effects.

One other relation was of interest—the effect on bearing temperature of changing oil flow as speed was changed. With oil flow constant, bearing temperature rose rapidly with the speed; with flow increased directly in proportion to speed, the temperature still rose with the speed but much more slowly; with flow increased as the square of the speed, temperature held nearly constant over the speed range from 1500 r.p.m. to 3000 r.p.m., then decreased quite rapidly as speed was further increased. This was, however, on the basis of constant oil inlet temperature which might in practice necessitate the use of an oil cooler where oil is to be recirculated.

Conclusions were then, for bearings of the type of automobile connecting rod ends in an enclosed casing, increase of oil flow has little effect in reducing temperature; cooling the casing by circulation of air will reduce bearing temperature but increases the coefficient of friction so as to affect oil consumption and deterioration of oil. To determine actual results of this method other experiments were necessary.

To Prevent Single Phasing

FUSES ARE now being mostly replaced by thermal cut outs which have the advantage of automatically closing the circuit again so that the motor operator can restart the motor after removing the cause of the overload. Where, however, an overload is unlikely to occur frequently, the fuse, if properly installed, will give complete protection.

Quite commonly the safety line switch is fused large enough to carry just the full starting load; then in case of a bad short during the starting period these fuses will blow. The motor is then started through a three-pole, double-throw switch, if it is small enough to put across the line. The up switch is marked Start and it is well to have a compression spring located so that it is impossible to leave the switch closed in this position. The down switch is marked Run.

Connect the Start direct to the safety switch leads and the Run to the underside of the motor fuses. Then make these fuses just large enough to carry the full load current. In this way you can start the motor without blowing the fuses and, as soon as it is up to speed, you snap it on to the Run side and are protected against single-phasing for no lead can carry more than it is designed for. If one of the running fuses blows, it is possible to start the motor; then when you change to the Run side it will single-phase and, if not carrying much load, it will continue to operate. This, however, will not hurt the motor and it can continue to do so for some time. As soon as the load increases so that the single phase becomes overloaded, another fuse will blow and protect the motor. On larger motors that are not thrown across the line, the connections are just as simple. Connect the starting side direct to the safety switch lines and running side through the motor fuses.

When motors are connected this way it is easy to test the fuses for, as long as the safety switch is closed, the running fuses are alive and all that is needed is to touch the leads of a test lamp to the motor ends of any two fuses. If the lamp lights, both must be good. If the lamp does not light, then one at least is blown. By testing each of these against the third one it is a simple matter to pick out the dead one.

Moline, Ill. GEORGE P. PEARCE.

Steam Trap Insulation

DISCUSSING the economy of insulating traps, in a recent issue of The Armstrong Trap Magazine, J. R. Armstrong gives some interesting figures as follows: For outdoor locations or where air circulation will increase radiation, possibly by 100 per cent, insulation is important, especially when high-pressure steam is handled so that the temperature difference between steam and air is large.

For low-pressure heating, a simple rule is that 1 sq. ft. of bare surface will radiate 3 B.t.u. per hour per degree of temperature difference, whether the vessel contains water or steam. If radiated heat is utilized in room heating, insulation may be of small consequence but, if wasted, the loss may be considerable.

Estimating steam to cost 50c per 1000 lb. and each pound of low-pressure steam to carry 900 to 950 B.t.u., every 900 B.t.u. radiated and wasted costs 0.05c, of which some 85 per cent can be saved by an economical thickness of insulation.

As to desirable thickness of insulation, a survey by the American Society of Heating and Ventilating Engineers indicates that ordinary practice is 1 in. thick for pressures up to 25 lb. (Temp. 267 deg. F.); for 25 to 100 lb., 1½ in. on flat surfaces or pipes over 4 in. diam.; for 100 to 200 lb., 2 in. on large pipes and flat surfaces, 1½ in. on 2 to 4-in. pipes, 1 in. on smaller pipes. If location is outdoors, all thicknesses to be increased ½ in.

As an illustration, for a 1¼ in. trap whose surface is 1.8 sq. ft., working at 50 lb. or 298 deg. temperature in a room temperature of 70 deg.; temperature difference will be 228 deg. and radiation will be $3 \times 1.8 \times 228 = 1231.2$ B.t.u. an hour. For 6 hr. a day and 365 days a year, this amounts to 10,785,312 B.t.u. and for 911 B.t.u. per pound of steam at 50c per 1000 lb. the yearly cost is $10{,}785{,}312 \times 0.50 \div (911 \times 100) = \$5.92$. Saving of 85 per cent is $5.03 by insulating the trap body for which at a liberal estimate the cost would be $1. That is a return of 400 per cent on the investment for the first year. How many traps are in your plant which will yield a similar return?

Motor Overload Capacity

FOR AN AVERAGE load of 5.5 hp. and a maximum load of 6.8 hp. over a period of one and a half to two hours, a 5 hp. motor should not be used. Under these conditions, the average load is 10 per cent over the rating of the motor and the maximum load is 36 per cent over the full-load rating. The torque thus imposed on the motor may reach 2 to 4 times the full load torque which may cause the motor to stop.

EDWARD W. JOHNSTON

Combined NH_3 and CO_2 Refrigeration Systems

TEMPERATURES OF FROM 50 TO 75 DEG. F. BELOW ZERO DEMANDED BY INDUSTRIAL PROCESSES CAN BE MET WITH DUAL SYSTEM, WHICH WORKS IN NICELY WITH EXISTING EQUIPMENT

INDUSTRIAL CONDITIONS and improved processes have been demanding increasingly low temperatures, often to from 50 to 75 deg. F. below zero. Oil refineries, packing plants, ice cream plants, quick freezing food plants and more recently fruit freezing plants have been in the forefront of those requiring lower and lower temperatures. Although the necessary low temperatures have been met by conventional ammonia and carbon dioxide systems, the refrigerant characteristics are such that combined systems using both, each in its most effective temperature range, have been developed.

Saturated ammonia gas at atmospheric pressure has a temperature of about —28 deg. F. For room or brine temperature of below about —18 to —20 deg. F., the ammonia system is under a vacuum. For a room temperature of around —40 deg. F., the vacuum is about 15 in. and the gas volume about 35 cu. ft. per lb. This volume requires large compressor cylinder capacity. Conditions in carbon dioxide systems are just reversed and with usual condensing water temperatures pressures on the high side run around 1100 lb. Its characteristics on the low pressure side are desirable for low temperature work, however, the pressure at —58 deg. F. being only 99 lb. abs.

Advantages of NH_3 in the high temperature range and CO_2 in the low temperature range naturally suggest

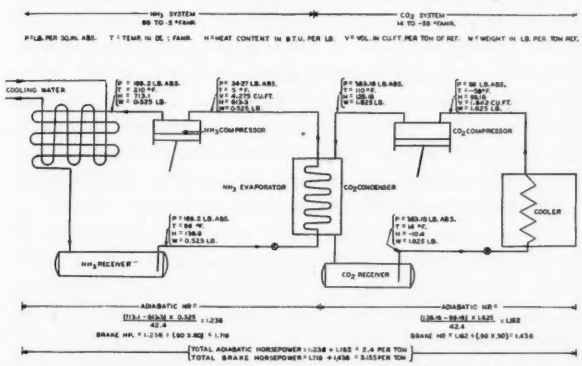


FIG. 1. THE COMBINED SYSTEM REQUIRES 2.4 ADIA. HP. PER T. OF REFRIGERATION

a combination of the two systems as shown in the diagram Fig. 1. In this system working between a temperature of —58 and +86 the CO_2 condenser is the NH_3 evaporator, making in reality two complete systems. Heat is picked up in the cooler by the evaporating CO_2, transferred to the NH_3 in evaporator-condenser and again transferred to the cooling water in the NH_3 condenser.

DUAL SYSTEM CALCULATIONS

Beginning at the right-hand side of Fig. 1, CO_2 passing the expansion valve and entering the cooler has a heat content of —10.4 B.t.u. per lb. Leaving the cooler at a suction pressure of 99 lb. abs., the heat content is 99.16 B.t.u. per lb. so that each pound of refrigerant circulated through the cooler absorbs 99.16 — (—10.4) = 109.56 B.t.u. As a ton of refrigeration is defined as 200 B.t.u. per min., 200 ÷ 109.56 = 1.825 lb. of CO_2 would have to be circulated for each ton of refrigeration.

Compression to 383.18 lb. abs. would superheat the CO_2 gas to a total temperature of 110 deg. F. and increase the heat content by the mechanical input of the compressor which is equal to 27 B.t.u. per lb., giving a total heat content of 126.16 B.t.u. per hr. at the compression discharge. As 1.825 lb. of CO_2 are being circulated per ton of refrigeration, the adiabatic work of compression is 27 × 1.825 = 49.35 B.t.u. per ton. As

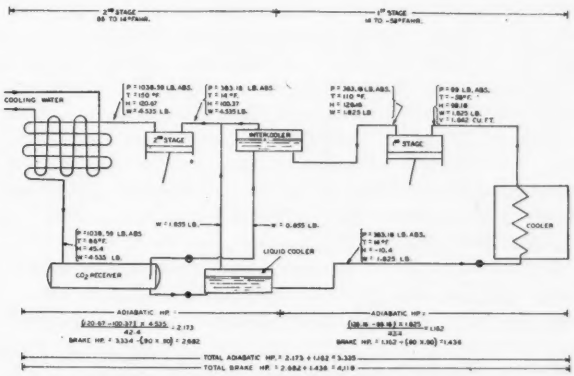


FIG. 2. THE TWO-STAGE CO_2 SYSTEM REQUIRES 3.335 ADIA. HP. PER T. OF REFRIGERATION

33,000 ft.-lb. per min. equals 1 hp. and 777.5 B.t.u. is equal to 1 ft.-lb., 33,000 ÷ 777.5 = 42.4 B.t.u. per min. equals 1 hp. Then 49.25 B.t.u. would be equal to 49.25 ÷ 42.4 or 1.238 adiabatic horsepower. Assuming a mechanical efficiency of 90 per cent and a compression efficiency of 90 per cent, the brake horsepower to the CO_2 compressor would be 1.238 ÷ (0.90 × 0.90) = 1.436.

In the condenser-evaporator operating with a temperature difference of 9 deg. F., the heat of 126.16 B.t.u. per lb. of CO_2 is reduced to —10.4 B.t.u. per lb., the heat being absorbed by the ammonia. This heat change can be calculated in two ways. It is equal to [126.16 — (—10.4)] × 1.825 = 249.25 B.t.u. per t. of refrigeration. It is also equal to the 200 B.t.u. represented by the ton of refrigeration plus the 49.25 B.t.u. of energy added by the compressor.

Ammonia enters the evaporator with a heat content of 138.9 B.t.u. per lb. and leaves at a suction pressure of 34.27 lb. abs. with a heat content of 613.3; a gain of 613.3 — 138.9 = 474.4 B.t.u. per lb. As the heat change per ton of refrigeration as calculated is but 249.25 B.t.u., only 249.25 ÷ 474.4 = 0.525 lb. of NH_4 per ton of refrigeration need be circulated.

At the compressor discharge, the heat content of the ammonia gas is 713.1 B.t.u. per lb., an increase of 99.8 B.t.u. per lb. in the compressor. The adiabatic horsepower per ton is, therefore, (99.8 × 0.525) ÷ 42.4 = 1.238 and the brake horsepower with 90 per cent mechanical and 80 per cent compression efficiency is 1.238 ÷ (0.90 × 0.80) = 1.719 hp. This gives a total

of 1.436 + 1.719 = 3.155 b.hp. per ton of refrigeration. The ammonia head pressure of 169.2 lb. abs. is fixed by the cooling water temperature. It is taken as 86 deg. F. as in the standard A.S.R.E. ton.

Two-Stage System

Naturally, this invites a comparison of a single refrigerant system operating over the same temperature range. This has been done in Fig. 2, representing a two-stage CO_2 system operating between the same temperature limits with an intercooler and liquid cooler. Operating under the same conditions as in the dual system, the first stage brake horsepower would be 1.436 as in Fig. 1. The second stage would, however, be much different and somewhat more complicated because of the two intermediate coolers.*

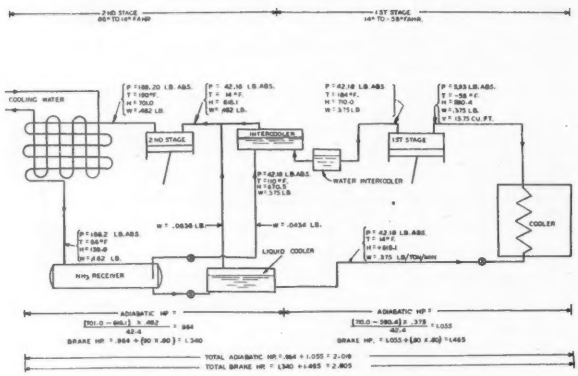


FIG. 3. THE TWO STAGE NH_3 SYSTEM REQUIRES 2.019 ADIA. HP. PER TON OF REFRIGERATION

Saturation conditions at the first stage discharge pressure of 383.18 lb. abs. is 100.37 B.t.u. per lb. so that there is 126.16 — 100.37 = 25.79 B.t.u. per lb. superheat which should be removed before the second-stage cylinder. Each pound of refrigerant flashing from receiver to suction pressure absorbs 100.37 — 45.4 = 54.97 B.t.u. so that (1.825 × 25.79) ÷ 54.97 = 0.855 lb. of CO_2 will be needed for the intercooler. In the liquid cooler, the liquid can be cooled to 14 deg. F. representing a heat drop of 45.4 — (—10.4) = 55.8 B.t.u. per lb. The flash vapor gains 25.79 B.t.u. per lb. as before so that to cool 1.825 lb. of liquid would require (1.825 × 55.8) ÷ 54.97 = 1.855 lb. for the liquid cooler.

Total refrigerant handled by the 2nd stage cylinder would then be 1.825 + 0.855 = 4.535 lb. With a specific volume of about 0.23 the suction volume is about 1.04 cu. ft. The second stage compressor adds 20.3 B.t.u. per lb., bringing the heat content up to 120.67 B.t.u. per lb. The adiabatic power input is (20.3 × 4.535) ÷ 42.4 = 2.173 hp. With compression and mechanical efficiencies of 90 per cent, the brake horsepower input is 2.173 ÷ (0.90 × 0.90) = 2.682. Total power input is 1.436 + 2.682 = 4.118 b. hp., which is 4.118 ÷ 3.155 = 1.305 or some 30 per cent in excess of the dual system.

Introduction of the intercooler and liquid cooler in Fig. 2 may appear to add an unnecessary load of 0.855 + 1.855 = 2.71 lb. to the high-pressure cylinder. A few simple calculations will show that the horsepower saving made possible by the two coolers is justified.

*Calculations for Figs. 1 and 2 by T. L. Warren, I. P. Morris—De La Vergne, Inc.

Coolers Decrease Compressor Power

With no liquid cooler, the refrigerant with a heat content of 45.4 per lb. would expand to the low-pressure suction pressure and would absorb but 99.16 — 45.4 = 53.76 B.t.u. per lb. so that 200 ÷ 53.76 = 3.72 lb. of refrigerant would have to be circulated per ton of refrigeration. This would increase the first stage adiabatic horsepower to (3.72 ÷ 1.825) 1.162 = 2.37 hp. With a water intercooler, reducing the low-pressure cylinder discharge to 86 deg. F., the gas, superheated about 72 deg. F., would go to the high-pressure cylinder and about 21.5 B.t.u. per lb. would be necessary to compress it adiabatically. The total adiabatic horsepower required would, therefore, be (21.5 × 3.72) ÷ 42.4 = 1.89 hp., giving a total of 2.37 + 1.89 = 4.26 adiabatic horsepower for both cylinders. With compression and mechanical efficiencies of 90 per cent, the brake horsepower would be about 5.25 hp. per t. or almost 28 per cent more than with the two coolers as in Fig. 2.

Two Stage NH_3 System

Addition of an intermediate water intercooler to the system is illustrated by Fig. 3 for a two stage NH_3 system (calculations by E. Baars, The Vilter Mfg. Co.). For this arrangement the total adiabatic horsepower is 2.019 hp. If the water intercooler were eliminated the 39.5 B.t.u. per pound removed by the water would have to be removed by the ammonia intercooler. This would increase the flow from the receiver to the intercooler 0.0316 lb. and the total refrigerant handled by the second stage from 0.482 to 0.5136 lb. and the second stage adiabatic horsepower to about 1.027 giving a total of 2.032 hp. per ton.

In Fig. 3 an ammonia compressor efficiency of 80 per cent has been assumed instead of 87 per cent as used by Mr. Baars in order to have Fig. 1 on a comparable basis. Using a compressor efficiency of 87 instead of 80 per cent would decrease the figure of 2.805 b.hp. of Fig. 3 to 2.582 b.hp. Obviously the mechanical and compression efficiency of the machines will vary with the size and design of machine so that in a study of this kind a comparison on an adiabatic basis is of more value.

Exact values of comparative power requirements of the different systems will vary considerably with a number of factors such as: the temperature limits available for specific conditions; charts used for calculations as these are often not in close agreement at the lower temperatures; equipment arrangement and allowances made for differences between actual and theoretical pressure-temperature relations. These differences have for some time been the subject of controversy by proponents of the two systems, each side advancing data to prove the superiority of its system. Power advantage of the dual system varies from zero up to about 30 per cent depending upon conditions; an average value, if such could be found, would probably be around 10 to 15 per cent.

This article is not intended to prove or disprove claims of either system, rather to point out the possibilities of a new development for certain assumed conditions. The dual system is adapted to existing ammonia refrigeration systems of both types and offers a practical method of increasing capacity and lowering the temperature of existing plants and giving a flexible system to meet present or future conditions. By means of multiple effect cylinders, four different temperatures can be obtained with the dual system.

Rectifier Efficiency Improved By Sectionalizing*

By A. L. Atherton
Westinghouse Electric & Mfg. Co.

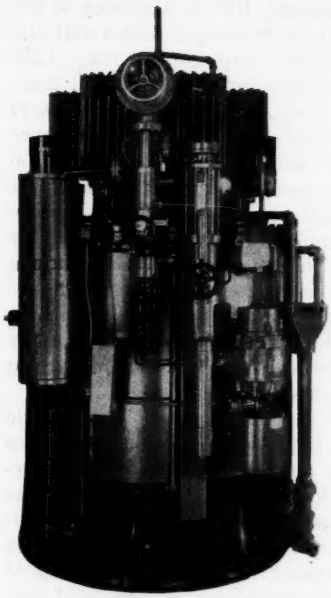


Fig. 1. Conventional Type 500 Kw. 600 v. Rectifier.

EVER SINCE THE general adoption of alternating current for the transmission and distribution of electrical energy there has existed a need for devices which convert alternating current into direct current. Among the various devices developed for this purpose the mercury arc rectifier has long held favor, first perhaps, because of its static nature, that is, the absence of moving parts, and secondly, because of its comparatively high operating efficiency. Its use, however, has been confined to applications of low power, since with high power, the mercury arc rectifier possesses limitations which until recently were difficult to overcome. With the recent development of the sectional type mercury arc rectifier, the restriction as to size has been largely removed and units of large capacity can now be expected to perform with perhaps the same degree of reliability that heretofore has characterized the small ones.

Small Units Effective

The sectional type mercury arc rectifier is based on the obvious, but apparently heretofore unrecognized, fact that the best possibilities inherent in the principle are realized only in the smaller sizes. Efficiency, reliability, and flexibility of both application and use are all far better in small than in large units. The advantages seem to be fundamental and therefore permanent.

Now, the rectifier is not alone in this. Many familiar things are inherently at their best in small sizes; some become impossible or impractical to make or use above a small unit size. A book, a bar of soap, a lead pencil among common things; the cylinders of an internal combustion engine, or the engine as a whole in mechanics; and among electrical things suspension insulators and incandescent lamps are examples. In each of these, and almost innumerable other cases, some kind of utility is added by the subdivision of the required amount into smaller unit parts. Imagine the Encyclopedia Brittanica in one volume, a lead pencil several feet long.

The established and common "unit type" things are so well known that we have come to overlook the limitations and inefficiencies introduced by the subdivision and to accept the scheme as natural and, therefore, right. In suspension insulator units, a large part of the insulation material is shunted by metal, assembly operations are duplicated many times in a single unit of use, and the distribution of potential along the string is wrong unless corrected; but the mechanical strength, flexibility, adaptability to all voltages, and the economy of concentrating manufacture and stocks in a single unit are so much more important that the disadvantages almost vanish from our thoughts.

So with the metal tank mercury arc rectifier. Subdivision into unit sections introduces both advantages and disadvantages, but the advantages so far outweigh the disadvantages that, once the conception is seriously considered and the sectional design actually worked out, doubts disappear and it seems the right and natural way to proceed.

Size Decreases Reliability and Efficiency

Development through the past 29 yr. has resulted in rectifiers of small capacity, 500 kw. for example, with a high degree of reliability, a reasonable cost, and an efficiency which makes available for the higher voltage conversion applications the unique quietness and freedom from mechanical wear which has provided the major incentive throughout the development. When size is increased to get larger output capacity, however, the quality decreases markedly. Reliability decreases not only in proportion to size as might be expected, but more rapidly because the complexity of the problem of control of the hurricane flow of vapor from the cathode is increased many fold when size is even doubled. The "outage time" per year with 3000 kw. rectifiers is several times as great as with 500 kw. units. Cost per unit of output does not decrease with increase of size, as it does with some apparatus, because manufacturing problems increase faster than in proportion to size, and because the total requirement for this kind of equipment, with capabilities and limitations as they are even in the smaller sizes, will not support organized "line manufacture" for the larger capacities. Efficiency falls off with increase in size because of the longer arc and greater exposure to deionizing surfaces, and because the fundamentally less reliability makes necessary an increase in loss producing devices to get acceptable quality. With present designs, the internal losses for a 500

*Abstract of a paper presented before the American Institute of Electrical Engineers in New York.

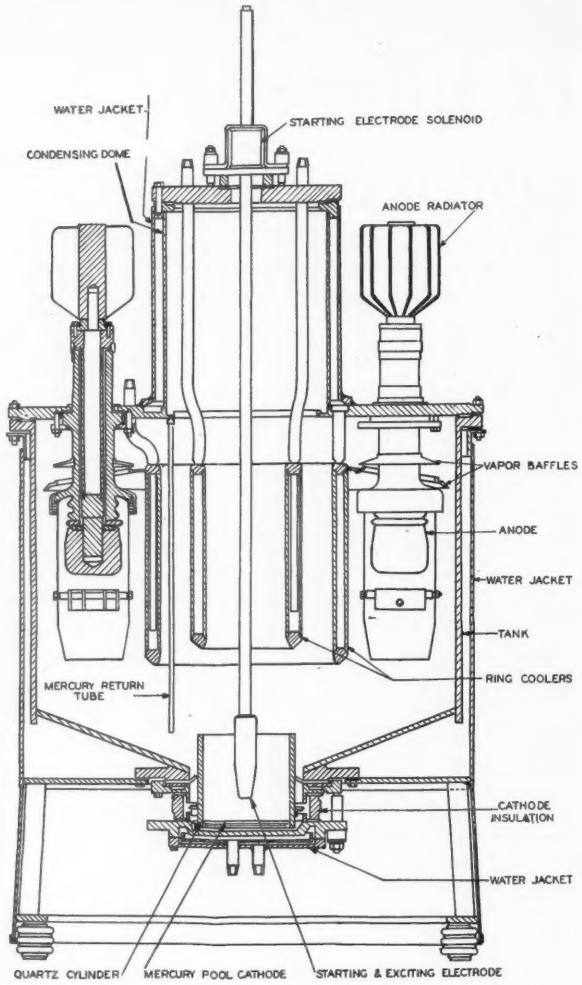


FIG. 2. SECTION SHOWING ARRANGEMENT OF PARTS IN CONVENTIONAL 500 KW., 600 V. RECTIFIER. THE DIAMETER IS 54 IN. AND THE OVERALL HEIGHT IS 104 INCHES

kw. unit are approximately 25 per cent less than for a 3000 kw. unit, both based on 600 v. operation.

If we think of multiple installations of conventional small capacity units of the sort which have been available in the past, we realize that the project is impractical. The space required is too great and the multiplicity of control and protective devices appears questionable. But when we think of subdivision of a large capacity, taking advantage of space economies resulting from recent advances in the art, building the structure in sections but installing, controlling, protecting and using it as a whole, the project becomes feasible and the desirable qualities of the small rectifier are made available for the larger capacities while the disadvantages of sectionalizing are so reduced as to become negligible.

Limits Fixed by Experiment

Our own work with rectifiers of conventional size and characteristics has resulted in the conviction that the limitation in capacity for a given design, as for example the 500 kw. unit shown in Fig. 1, lies in local limitations of the various parts, for example, the limits of conductivity and heating at the anode, and not in the perhaps more fundamental and difficult tendency to arc back at the higher currents. For example, such a unit carries a nominal current of 833 amp. continuously, 1250 amp. for 2 hr. and 2500 amp. for 1 min. In all tests, including use at currents up to 17,000 amp. on short circuit, and with considerable experimental experience on loads of 2000 to 2500 amp. for periods of 5 to 30 min. dependent on temperature rise, arcing back was not found to be a limitation. Extended service experience with a limited number of installations gives the same result. Evidently, change in the details, leaving the general arrangement unaltered, would make it possible materially to reduce the size of the containing tank without affecting the ability of the unit to carry the loads required by its rating. Experiments along these lines have verified this conclusion.

As a further step, a rearrangement of parts made possible a still further reduction in size for a given rating, and at the same time brought about some reduction in the internal losses. The rearrangement was based on the knowledge gained by experimental experience as to the effect of the way the vapor flows from the cathode to the condensing wall and the position of the anode structures in relation to this stream of ionized vapor on the limiting current of which the rectifier unit is capable, without excessive arcing back. Although the whole mechanism of vapor flow and its effect on arcing back are far from known, several factors which influence performance have been established. The design shown in Figs. 3 and 4 is an attempt to take these as yet rather intangible and, it must be admitted, somewhat uncertain factors into account in the most satisfactory way possible at the present time.

The anode support and shielding arrangement also offered an opportunity for progress and a rather extended series of experiments resulted finally in the anode structure shown. Processing to eliminate foreign material and keep the gas evolution under operation at as low a value as possible, have progressed along with the design development.

As a result of these improvements, the rectifier section shown in Figs. 3 and 4 is capable, with a reasonable

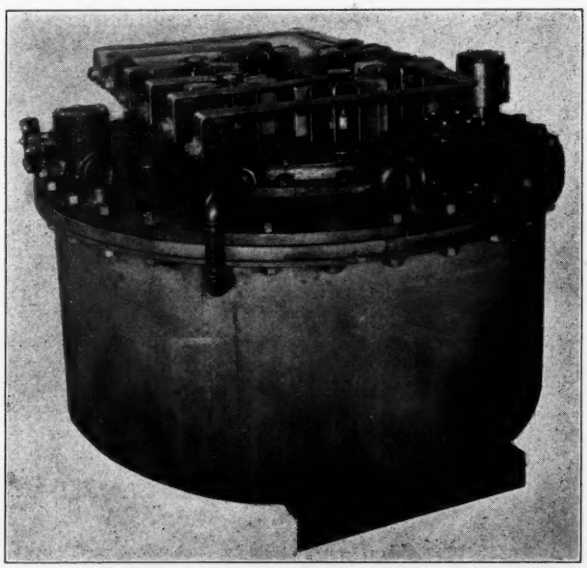


FIG. 3. RECTIFIER SECTION, 750 KW., 600 V. RATING

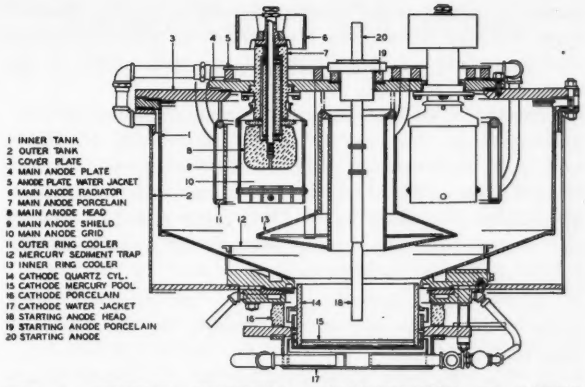


FIG. 4. SECTION SHOWING ARRANGEMENT OF PARTS OF UNIT SHOWN IN FIG. 3. THE DIAMETER IS 54 IN. AND THE OVERALL HEIGHT IS 41½ IN. THE KW. RATING PER UNIT VOLUME IS THUS OVER 3 TIMES AS GREAT AS FOR THE CONVENTIONAL UNIT

margin, of a standard nominal rating of 750 kw. at 600 v., and even of higher short time overloads as sometimes required.

This section, at 750 kw., 600 v. rating, is required to carry a normal current of 1250 amp., with 50 per cent overload or 1875 amp. for 2 hr. Owing to the fact that final temperatures are reached in times of the order of two hours, it is felt that the two-hour capacity can best be indicated by continuous operation at the 50 per cent overload value and our experimental tests have been made in this way, thus including in a single test some margin of safety along with a degree of acceleration of the test. Double load, or 2500 amp. is required by standard nominal rating for a period of one minute following full load. Experimental tests have been made at this current up to 5 min. duration.

In all these operations, arcing back is very infrequent if it occurs at all and it is a requirement that the rectifier can be put into operation again immediately following such an occurrence.

Losses

The internal losses in the rectifier are determined by the arc drop, or voltage from anode to cathode during the conducting period. This value varies with load current and can be indicated by a curve of voltage drop against load current. The value that determines efficiency is the average for the various anodes. Fig. 5 shows average arc drop curve for the unit indicated by Figs. 3 and 4. The dotted curve shows the value for the older, conventional, unit shown by Fig. 1. As the size of a rectifier is increased, the arc path becomes longer and losses per kw. output become greater. Experimental rectifiers of 3000 kw. with a single tank have had arc drop values as shown by the dot and dash curve of Fig. 5. It is seen that at full loads the difference between these experimental single tank 3000 kw. rectifiers and the section shown in Figs. 3 and 4 amounts at full load to approximately 6 v. or 1 per cent on the basis of 600 v. output. With ordinary load factors and rates for power, this difference in 3000 kw. rating saves from $600 to $1500 per year power cost, which represents an added value of from $4000 to $10,000.

The proportions of the new units are such as to make it feasible to mount them in service one above another. Thus, a 3000 kw. unit can be made of four

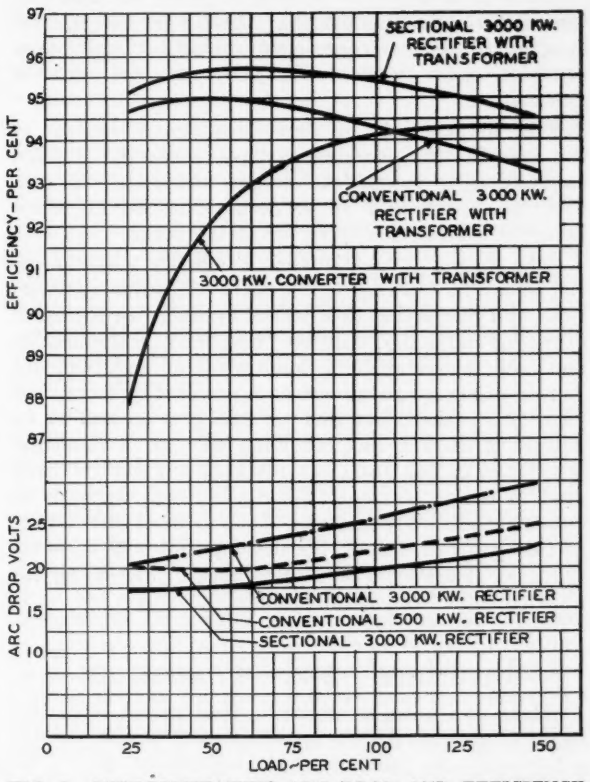


FIG. 5. REPRESENTATIVE ARC DROP AND EFFICIENCY CURVES FOR CONVENTIONAL AND SECTIONAL RECTIFIERS

750—kw. sections mounted two side by side and two deep. Such an arrangement is shown in Fig. 6. The floor space required for such an assembly is approximately 118 in. wide by 68 in. deep over all parts, including auxiliary equipment. The overall height is 113 in., and the ceiling height of the room necessary to accommodate this equipment need not exceed this value except for electrical clearance of a few inches and whatever may be necessary to provide for adequate working space certainly not more than two feet. It is evident that there is a considerable space economy.

FIG. 6. A 3000 KW. SECTIONALIZED MERCURY ARC RECTIFIER COMPOSED OF FOUR 750 KW. SECTIONS, INTEGRALLY MOUNTED, FED FROM A SINGLE TRANSFORMER AND MOUNTED ON ROLLERS

Such an arrangement is likely to prove the most convenient for usual applications. There is no reason, however, why other arrangements cannot be used where available space places a limitation on one or more dimensions.

One arrangement of vacuum pumping consists of two independent pumping systems, connected through manifolding to the various sections and with cross connections so arranged as to permit the use of either pumping system on any or all of the tanks.

The project for sectionalizing together with the development in working out sections of suitable dimensions and proportion thus makes available an increased degree of reliability, increased flexibility in application and use, improvement in manufacturing requirements, and an efficiency advantage of 1 per cent or more. Beyond this is the belief that as time goes on and as we acquire a clearer understanding of the fundamental knowledge gained from our research but not yet fully used in design, further improvement will be made in respect to efficiency and size. It is to be expected that, as this progress occurs, the development will be along the lines of sectional structures rather than along the lines of single unit arrangements.

"Inverters" and "Phanotrons"

MORE AND MORE, as electrical development continues, electron tubes are finding applications in industry. Only a few years ago vacuum tubes were known only to the radio engineers and for them they performed wonders, but little use was found for them elsewhere. Then, a few of them ventured timidly from their birthplace in the radio field and went to work in a few specialized jobs in the factory. While these first applications were somewhat in the nature of experiments, no one questioned their ability to perform, and even in those early days, ambitious predictions were made of their future place in industry.

That this confidence in the future of the electron tube was not misplaced is quite evident from the increasing use to which these devices are being put in all branches of industry. Today they are no longer simply adaptations and experiments, they are considered necessary.

Outstanding among the many different types of electron tubes available for use in industry is the thyratron, of three-element hot-cathode gas-filled tube with grid controlled arc. Among the many interesting and valuable applications of this tube which have been devised is the "inverter," described by F. N. Tompkins at the Providence meeting of the American Institute of Electrical Engineers, May 4 to 7. The purpose of the "inverter" is the inversion or changing of direct to alternating current, the reverse processes of the more usual rectification. With the advent of the thyratron with its high efficiency, low voltage drop, and its ability to handle the comparatively large amounts of power, the inverter gives promise of becoming of commercial importance.

Inverter circuits may be divided into two main types, series and parallel. While for the former type many data have been published and many different circuits have been devised, very little beyond the fundamental circuit has been given for the latter. In Mr. Tompkins paper he presents the results of a study of the parallel-type inverter which was undertaken to secure a better understanding of the functions of each part of the operation as a whole.

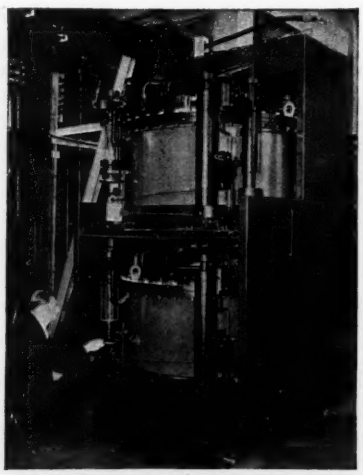
Another paper of interest presented at the Providence meeting was one by H. C. Steiner, A. C. Gable and H. T. Maser on the Engineering Features of Phanotron Tubes. Phanotron is the name which has been applied to the gas or vapor filled electron tube. Among the outstanding engineering features of these tubes the following facts are important:

1. The tubes are static devices, the complete functions of which are performed through the movement of ions and electrons.
2. The efficiency in controlling or converting power is high. Tube efficiency ranges from 95 per cent to over 99 per cent.
3. Control is flexible and the power required for control is small.
4. The speed of operations as a relay is extremely fast and in addition, the tube may function cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.
5. Noise and vibration are entirely absent.
6. Current carrying capacity is available in the range from a few milliamperes to several hundred amperes.

In practice the name phanotron has become associated with the two element or simple rectifying tube. The phanotron tubes in which the starting of the conduction period is controlled electrostatically by the action of one or more grids have been termed thyratron tubes.

New Sectional Mercury Arc Rectifiers

IN THE ACCOMPANYING photograph is shown the latest product of the Westinghouse Electric and Manufacturing Co. in mercury arc rectifiers. More efficient and much smaller than a conventional rectifier of the same rating, this 1500 kw. unit, shown on test in the Westinghouse laboratories, consists of two interchangeable units, rated at 600 v., 750 kw. mounted on rollers, one above the other. The engineer is reading the vacuum in the lower section.



Power Factor Correction

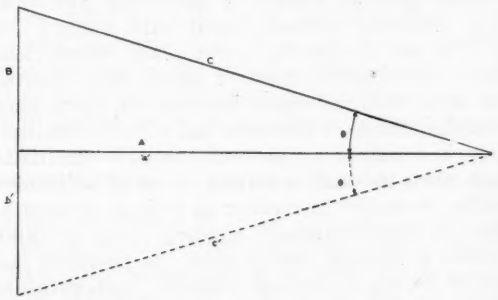
By F. S. Park*

THE AVERAGE operating power engineer has not given study to the importance of power factor correction that he has other phases of his profession.

Except, perhaps, in the boiler room, losses can be greater through low power factor than any other item in the generation of power.

Engineers often diligently watch their CO_2 recorders and stack temperatures, while the power factor indicator just gets a passing glance.

A further insight into the intricacies of the subject is worth-while. Some text books illustrate the idea through the medium of a boat crossing a river, whose flow represents inductance of an alternating current circuit. Should the student not be nautically inclined, he is liable to flounder mid-stream in trying to grasp the significance of the author's picture. He wanders then into a maze of vector diagrams, necessary of course to the designer and of great help and assistance to one



POWER FACTOR DIAGRAM

who desires to master fully this interesting problem, but there are other ways of explaining it.

Let us look at it from another angle, much simpler and to the point. First, we must visualize two factors, the names of which are almost self-explanatory—induction and capacity, both terms being used in conjunction with reactance.

We will now draw a right triangle to illustrate the point. The base A represents kilowatts; the hypotenuse C represents kv-a. or Volts × Amps. × 1000; side B or the altitude represents reactance, induction in the case of B and capacity in the case of b′.

We know that k.w. = kv-a. × p.f. A glance will show us then that as the power factor approaches unity our hypotenuse or kv-a. approaches the base or kw. and side B which represents inductive reactance, becomes smaller and it is this inductance that we must try to reduce. From this same triangle we can by substituting values taken from our meters and by a simple formula, check our power factor.

Power Factor we are told is the cosine of the angle of lag or lead. By lagging we mean when the current lags behind the voltage, due to the inductance represented by side B in our triangle; by lead we mean when the current leads the voltage, due to capacity, as side b′. To find the cosine, we simply divide the base by the hypotenuse C or kw. by kv.-a.; from a table of sines and cosines we can readily find the angle.

*Power Engineer, Pacific Goodrich Rubber Co., Los Angeles, Cal.

We must not forget, however, that the loss from a lead or lag is the same, and although we may have a lead on a particular unit it is only with the idea of trying to raise the total power factor on the prime mover or the system.

Practically all a.c. generating equipment and transformers are rated in kv-a. and it is quite obvious that this factor increases with the altitude of the triangle or reactive component. The significance of this summary will indicate that we can approach or overrun the capacity of our prime mover or transformer without actually increasing the base of the triangle or kw., which in turn represents actual power output. Our problem then is to reduce the side B of our triangle or reactive component, often termed wattless power or wattless component.

One of the principal causes today of low power factor in most isolated plants is the under loaded induction motor brought about by rule of thumb estimating of the motor capacities necessary for various drives; the same thing applies to a bank of transformers, although in some cases this can be excused, due to allowance for expansion, but with the motor there is no excuse; apart from the continuous loss there is the first cost to be considered. Induction motor installation is of prime importance, and a careful analysis of power requirement is necessary. It is advisable under some conditions to take the mean average load and resort to a higher temperature rise motor to take care of overloads that may appear at short intervals. Let us now take a simple example for illustration. Assuming a load of 4000 amp. at 440-V.; Amps × Volts = 1,760,000, or 1760 kv-a. Assuming 60 per cent p.f., = 1256 kw.; the same load at 80 per cent p.f. = 1424 kw. or a difference of 168 kw. or 225 hp., and this same 225 hp., is like so much unburned combustible going up the stack. What our working example has shown then is that we have 168 kw. wasted. We could, then, install a synchronous unit with a leading power factor, which would give us this available energy.

In plants where electrical energy is bought from a central station, this subject is just as important as to the plant generating its own power.

Most power companies today have a power factor clause in their contracts, some of them varying with their methods but all more or less self-explanatory.

The most common is that of an additional kv-a. demand charge of anything from 50 cents to $1.00 per kv-a. We can again substitute some values assuming a maximum demand of 5000 kw.-hr.

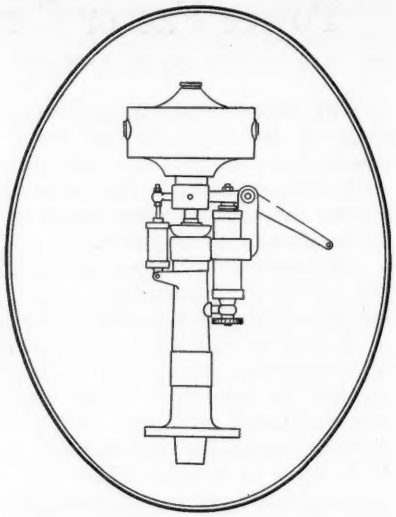
at 60 per cent p.f. our kv-a. would be 5000 ÷ 0.60 = 8333
at 80 per cent p.f. our kv-a. would be 5000 ÷ 0.80 = 6250
at unity p.f. our kv-a. would be 5000 ÷ 1.0 = 5000

the demand charge at unit cost of 50 cents would then be $4166.50, $3125.00 and $2500.00 respectively. Amounts such as these apply to large consumption.

Other companies give a more apparent direct saving to consumer; this system is to subtract the reactive volt amperes (r.v.a.) reading from the kw.-hr. reading allowing a reduction of 0.7 to 0.8 mills per unit difference.

Many plants that are now using synchronous equipment, can better their power factor conditions by maintaining as high a field current as is designated by the manufacturer and still more by raising the voltage on the excitation circuit, especially when a number of synchronous motors are excited from a common bus.

DIESEL ENGINE UPKEEP



PART XXIII GOVERNOR CLASSES AND REQUIREMENTS. WEAR, REPLACEMENT AND LUBRICATION. HUNTING EFFECT. GOVERNORS AS TROUBLE INDICATORS. BOOSTER ATTACHMENTS AID LOAD CHANGES.

BY EDWARD J. KUNZE

GOVERNORS USUALLY are employed to maintain uniform speed of the engine. For this purpose, generally, they are of the centrifugal type such as shown in Fig. 1. Another type, which is used to some extent, employs the inertia of its weights as well as centrifugal action to operate the mechanism used for regulating the speed. Inertia acts when sudden changes in speed are likely such as when the load is thrown off suddenly from the engine; centrifugal action moves the mechanism when the load change is gradual. In the shaft governor, illustrated in Fig. 2, the weight swings so slightly on the pin from which it is hung that lubrication is difficult hence extra care should be given to this bearing. Use of a loose bronze bushing at this point reduces the amount of wear.

BRONZE BUSHINGS AS REPLACEMENT PARTS

Wear on centrifugal governors occurs principally at the links and pins. Use of bronze bushings, which may be replaced easily, is preferable because rereaming of the links and turning up of new pins is more costly and requires more time than replacement of bushings. Inspection of the governor mechanism should be made once a year and bushings replaced before they become badly worn. Ball bearings, where used, should be examined also at this time.

CLASSES OF GOVERNING

Three general classes of governing are found in Diesel practice; constant speed with varying load as found in electric-lighting power plants where close regulation is required; constant speed with intermittent load, as in hoisting engine installations where moderate speed fluctuation is allowable but where a sensitive governor is required to prevent excessive fluctuation in speed when the load is thrown on or off suddenly; and thirdly, overspeed governing as used to prevent racing when the load is dropped suddenly, such as in marine practice to prevent racing when the propeller is lifted clear of the water in rough weather. Such governors are usually of the inertia type so as to insure quick action.

In order to function correctly for a given service, a governor should have adequate sensitivity, stability, responsiveness and power to satisfy the condition of operation. Close regulation of an engine's speed requires the governor to be sensitive to speed changes. Therefore, it should have a minimum of frictional resistance or too great a speed change will be required before the governor will respond. Sluggishness of a governor may be reduced by careful lubrication of not only the joints and bearings of the governor itself but of the entire governing mechanism from governor to fuel-control valve.

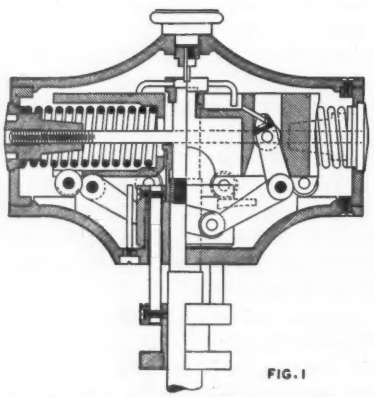


FIG. 1

FIG. 1. JAHNS TYPE CENTRIFUGAL GOVERNOR

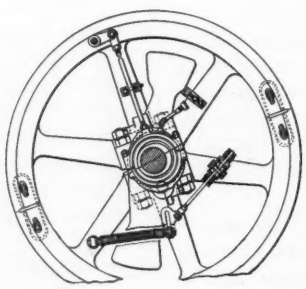


FIG. 2

FIG. 2. RITES INERTIA SHAFT GOVERNOR

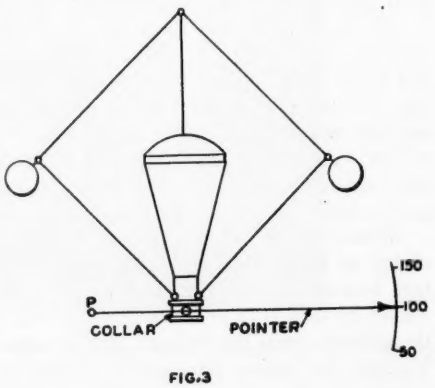


FIG. 3

FIG. 3. TACHOMETER ARRANGEMENT ATTACHED TO CENTRIFUGAL GOVERNOR

Adequate lubrication of governor-shaft and cam shaft gears, where used, is important. Stream lubrication is usually adopted for this purpose but the oil must be fed in a heavy stream so as to assure maintaining a film of oil at the pressure line between the two contact teeth at all times. If tendency to cut is observed, an oil with a heavier body should be used.

Governors May Be Too Sensitive

Under certain conditions sensitivity of a governor may be increased to such a degree as to cause it to become unstable.

Over sensitivity may result in a "hunting" effect wherein the governor is constantly changing the position of the weights in order to meet the engine speed changes. To avoid this, governors are fitted with dash pots to dampen erratic action.

Although the charge in any internal combustion engine, especially of the four-cycle type, is out of control of the governor for a much longer period before its employment in the engine cylinder than is the case with a steam engine, the use of many cylinders instead of just one or two as in the steam engine partially compensates this inherent defect. Even within the period of control of the charge, the action of regulation is much affected by the effort which must be expended upon the fuel-pump mechanism to alter quickly its rate of operation.

Governors May Indicate Improper Engine Operation

Fluctuation of three per cent from no load to full load is considered satisfactory for Diesel lighting plants. For ordinary load changes such as occur during operation this would correspond to about one per cent fluctuation. Since change in speed indicates some abnormal condition, it is convenient to attach a speed indicator to the governor so that any such change in speed may be noted quickly by the operator. A simple method of doing this is shown in Fig. 3 in which an indicator arm is hung on a fulcrum pin, P, which is fastened to a stationary post and is passed through the governor collar slot.

Close speed regulation requires a high degree of responsiveness on the part of the governor and this is influenced by the inertia of the weights to be moved, the power of the governor and the amount of friction involved. To secure great power and small inertia effect, light weight and high speed are required. It is necessary, then, to use a spring for the counterpoise.

Governors Must Have Adequate Power

Since the regulation of the charge in Diesel engines involves use of light parts only, not much power is required to operate the governing mechanism and direct acting governors may be used but the governor should have adequate power to actuate the mechanism within reasonable speed fluctuations for any condition of operation. If compounding the leverage mechanism for the purpose of increasing the sensitivity of the governor is contemplated, assurance must be had that the governor will have sufficient power to operate the mechanism.

Booster Attachment for Quick Load Changes

Where quick handling and large overload capacity is necessary, such as in ferry boat service, a booster attachment has been devised which operates satisfactorily in conjunction with the Ward-Leonard system which is used frequently in this service. This booster cannot be used with generators operating in parallel because the division of load would be unstable but it functions well with single units or those connected in series. Action on the governor is in proportion to the load; with no load there is no action. The governor is adjusted to give the desired speed with no load, then the booster is adjusted to give a slightly higher speed with full load.

Regulation of the booster is secured mainly by sliding the connecting link in or out on the booster arm.

In constructing the booster the armature of a two-pole, shunt-wound, direct-current motor of suitable size

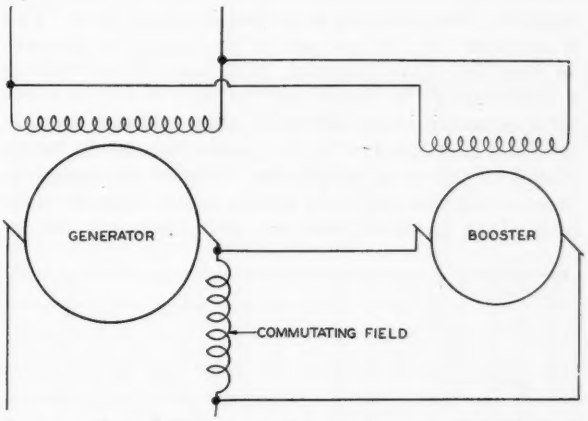


FIG. 4. DIAGRAM OF ELECTRICAL CONNECTIONS FOR BOOSTER USED WITH GOVERNOR FOR WARD-LEONARD ELECTRIC DRIVE

and voltage is rewound and connected up as shown in Fig. 4. The field may be connected either across the line or across the commutating field as shown. Lower voltage results with the latter connection but the field strength is not always directly proportional to the voltage of the main circuit. With the lower voltage, the armature winding and connections must be of low resistance.

Considerable amount of copper wire is required to obtain sufficient torque and, to provide adequate winding space, some of the armature teeth are cut out. Use of heavy wire or of a number of smaller wires in parallel is required to keep the resistance low. The size of the motor required is determined by the available power of the governor and the amount of power required to regulate the fuel pumps. In no case should the armature be less than 3 in. in diameter. The armature winding must be suited to the voltage across the commutating field. If the generator has any series field winding, this winding and the commutating field should be connected in as a shunt. If armature and field are both to be rewound, it is preferable to wind the armature for voltage and the field poles for current.

Where engines are being used in the service for which they were purchased, governor adjustments should be made according to directions given by the manufacturer and replacement parts such as springs and bushings should be kept on hand. If, however, the load or operating conditions have been changed, adjustments or attachments may be necessary but before making changes it is best to consult the manufacturer.

Readers' Conference

Relative Sizes and Proportions of Coal Particles

HAVING considerable experience with sieve testing on different materials, I was much interested in the pulverized coal article by Theo. James in the February 15 issue. Pulverized fuel was very successfully used in cement and metallurgical mills and furnaces long before it came into use in power plants. Each material has a characteristic fineness distribution which is easily seen when the sieve analysis is plotted in graph form. This is mentioned in the last part of the article by Knabner on page 790 of the August 1, 1931, issue. When making a sieve test, it is always well to plot it out in curve form because it is not difficult to make mistakes on these tests and mistakes show up on a curve because the points should all fall on a straight line. Most of the variations in materials that are found are the result of poorly made tests. In a machine, tests are quite consistent but by

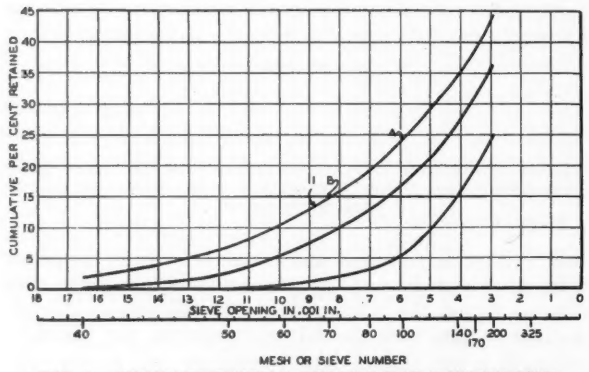


FIG. 1. CHARACTERISTIC CURVES FOR PULVERIZED COAL

hand there is a great difference on the small sizes with different men and different methods.

Graphs can be made in a number of ways, one of the most valuable being the type shown by Fig. 1. On the bottom scale is the size of sieve opening either in inches or in mesh or both as shown. The vertical scale is the cumulative per cent retained on any given sieve. That is, you have a nest of sieves, say the 40, 50, 70, 100, 140 and 200. You screen the dust through from the coarsest to the finest and weigh what remains on each screen and what passes through the finest screen to the pan. The sum of all these remainders plus the amount through the finest sieve should total up to the weight of the sample. Then you convert each of these weights into per cent, say for example 3 per cent on the 40; 4 per cent on the 50; 8 per cent on the 70; 9 per cent on the 100; 11 per cent on the 140 and 9 per cent on the 200 sieve. Then you start at the coarsest sieve and add up these percentages so that you would get the total weight that would be retained on any one sieve in the series if you had no coarser one above it. Adding up the foregoing percentages would give 3, 7, 15, 24, 35 and 44 per cent respectively for the sieves mentioned. This has been plotted on Fig. 1 as Curve I.

Sometimes these are plotted from right to left as in the article mentioned above, but I prefer to plot them from left to right as I have shown. If you are using the actual size of the holes, it is perhaps better to go the other way because the zero will be at the left; but if you use mesh as most people do and as is done on the inside of the bottom line, the smallest sieve is at the left as I have shown and it is better to have the scale increasing to the right because there is less chance of making mistakes. Most old timers used Tyler sieves and they put out forms and curve sheets for calculations in this way. Most of the sieve numbers I show are U. S. Standard (A.S.T.M.) numbers simply because the data I had happened to be taken with them. As a matter of fact, the two are practically the same when you remember that 28 Tyler is 30 U. S.; 48 Tyler is 50 U. S. and 150 Tyler is 140 U. S. The others are just the same.

Figures in Fig. 1 were taken from the N.E.L.A. publications. They are tests from the same plant on one middle west coal at different finenesses. You can see from point A that 24 per cent of the coal would be retained on the 100 sieve, this is called plus 100 mesh. The remaining 76 per cent would go through this sieve and is called minus 100 mesh. At point B, 15 per cent would be retained, the 9 per cent between the 70 and 100 sieve is called minus 70, plus 100 meaning it will pass the 70 but not the 100 sieve.

Figures given by Theo. James are very coarse for pulverized coal. Usually it is finer than 60 per cent through 200 whereas most of his points are below this. He must have a very big furnace and the carbon loss must be high. Of course his A plus C line (if he plotted it) would have to be a straight line, but the B line, the amount through 100 mesh, might not be. It probably is below 50 per cent through 200 mesh but above this it apparently curves off sharply to the right.

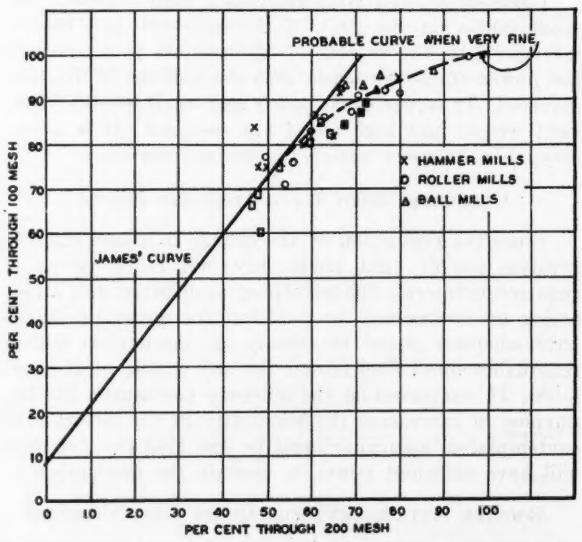


FIG. 2. THE RELATION BETWEEN THE PERCENTAGE THROUGH THE 100 AND 200 SIEVES SHOWS A DECIDED CURVE AS THE PERCENTAGE THROUGH 200 IS INCREASED

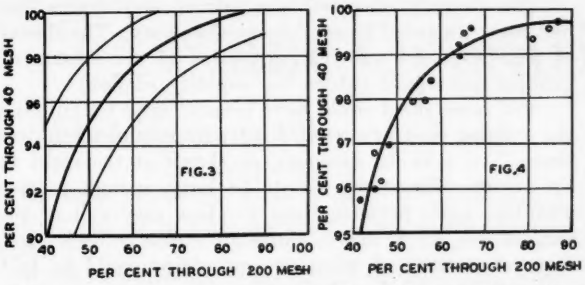


FIG. 3. RESULTS OF TESTS ON MANY DIFFERENT TYPES OF COAL AND MILLS. THE AREA BETWEEN LIGHT LINES REPRESENTS THE EXTREME SPREAD OF THE POINTS
FIG. 4. TEST RESULTS FROM A SINGLE PLANT SHOW CLOSE AGREEMENT

As Theo. James suspects, there is a definite relation between the amount through 200 mesh and the amount through the other sieves. For the past several years many pulverized coal men have said that it is sufficient to say that all or a very high percentage should go through 40 or 50 mesh (which can be tested easily) rather than specifying 200 mesh where the test is more difficult to make accurately. Just what the relation of a percentage through 50 or 100 mesh for a given 200 percentage is not definitely fixed. Some say that this relation is a function of the mill used for grinding, some say it depends on the coal, some say it depends upon both factors and some say that it is independent of both. When you plot up the figures given for tests, so many of the points are obviously wrong that one who has had considerable experience and knows how much difference the sieving procedure makes is tempted to believe that those who feel that the fineness distribution is independent of mill and coal have some basis of fact, although certainly some coals are more friable than others and it would seem reasonable to suppose that a difference in fineness distribution might be expected.

In Fig. 2 I have traced Theo. James' B curve, the percentage through 100 mesh, and on it I have plotted a number of tests from data published by the A.S.M.E. and N.E.L.A. on all types of mills from all over the country. The squares mark tests from one single plant. There is a decided curve in the common working range of 55 to 70 per cent through 200 mesh. This curve holds true for the 40 mesh as well and Fig. 3 is from 1928 tests (A.S.M.E.), showing how the percentage through 40 mesh varied. The curve is well defined from over 100 tests on seven types or kinds of mills. The portion between light lines shows area covered by most extreme points. Figure 4 from data in the same A.S.M.E. paper is for tests from a single plant. Again we cannot determine whether the difference in Fig. 3 is from the mill, the coal or the method of making the sieve analysis. Undoubtedly other plants using all types of mills and coal have any number of such tests as Mr. James shows, and getting them all together should bring out some interesting and important data.

Theo. James mentioned the lack of 50 mesh data. It is not necessary. If he will get several complete tests on the same kind of coal for different per cents through 200 mesh, he can draw characteristic curves and find the probable percentage on or through 50 mesh from his old tests by using the old 100 and 200 mesh figures and curves such as shown by Figs. 1 or 4.

Springfield, O. F. PAUL.

Stoker Control by Steam Temperature

AMONG MANY possible uses of the expansion type regulator a rather ingenious one is that of boiler pressure control. It will be found that extremely sensitive control for maintaining constant pressure will be given by such a regulator in a case where it is possible to use one.

In the illustration, the boiler operated at a steam pressure of 150 lb. gage and a venturi reducing valve supplied steam at 150 to 2 lb. pressure ratio for heating. This line was always open when the boiler was in operation. The boiler was fired by an automatic stoker driven by a vertical steam engine the speed of which was controlled to maintain constant steam pressure.

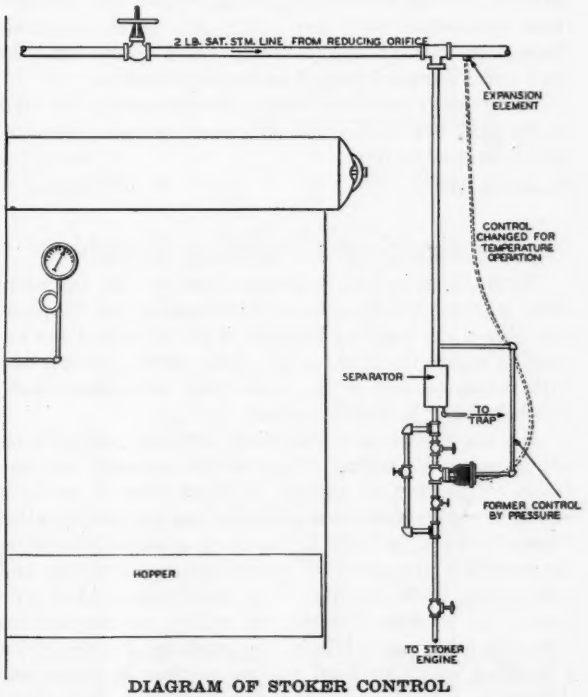


DIAGRAM OF STOKER CONTROL

The temperature of the saturated steam varies about 20 deg. per pound pressure change at this pressure (2 lb.) and in such a case as that mentioned the boiler pressure will always be in direct ratio to the reduced pressure. The regulator will change the stoker speed on a steam temperature change of a few degrees and will control the boiler pressure more nearly constant than a regulator operating direct from the boiler pressure.

Boston, Mass. HARRY M. SPRING.

Commutator Had One Bar Too Many

FOR A 25-HP., direct-current motor the armature had suffered a burnout by reason of accidental opening of the field circuit while the machine was running and was replaced immediately with a duplicate, which was kept in reserve in anticipation of just such an emergency. When the motor was again started, the commutator brushes persisted in sparking furiously, the sparking being localized in a narrow strip of the commutator's

circumference. All attempts to stop it by shifting the brushes were fruitless.

Finally, an exchange of armatures with another motor of the same type and rating was tried. The offending armature continued troublesome in its new location, while the one for which it was exchanged worked perfectly, which seemed to indicate that imperfect armature construction was the cause of the difficulty and so it proved.

Some time back, the defective armature had been sent to a repair shop for overhauling and putting on a new commutator. A proper job would, of course, have given the new commutator as many segments as the armature had coils, each coil having two leads for connection to two adjacent segments. Close examination showed that one bar too many had been put into the commutator, leaving a dead copper bar which had no electrical connection with any other part of the machine. Thus there was an angry arcing spark every time the dead extra segment passed under the brushes.

The remedy consisted simply in connecting the ends of the dead bar to the ends of one of the properly connected bars adjoining.

St. Louis, Mo. D. J. ALTIZER.

Eliminating a Packing Trouble

EVERY ONCE in a while I learn from various engineers about packing troubles caused by expansion of the packing. When the packing gets hot it expands and the expansion makes the packing too tight, thereby interfering with the movement of the piston rod, valve stem, shaft, or whatever it is that is packed.

For the condition of this kind, the best possible remedy is to use a packing which neither expands nor contracts on heating or cooling. I know there is at least one such packing on the market this one being a so-called "metallic packing". It is based on a metal possessing the desirable property of expanding upon cooling and contracting upon heating. It is therefore an ideal substance for packing because, in reality, in conjunction with the other materials in the packing, we are given a packing which in total volume neither increases nor decreases, regardless of the temperature. This metal withstands temperature in excess of 1200 deg. F. and resists corrosion from acids, alkalies and electrolysis.

I recall that years ago it was thought that packings could not be improved. We thought we had the last word in packings. But, surprising, as it may seem, improvements are being made right along and I dare say they will continue to be made for many years to come—as long as human beings are capable of thinking constructively.

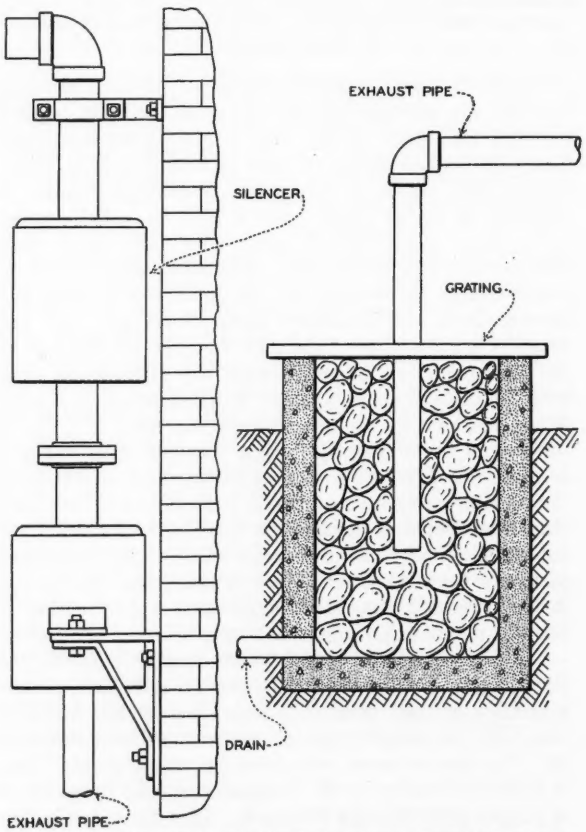
45 Academy St. W. F. SCHAPHORST.

Silencing Engine Exhausts

MUFFLER attached to the exhaust pipe of an internal combustion engine operating on producer gas was not effective in producing quick running without adjusting it so as to put too much back pressure on the engine. Complaints against the noisy exhaust finally compelled the man in charge to adopt some means of relief. The problem was to abate the nuisance without lowering the engine's efficiency. The figure at the left in the sketch shows the operating man's method of solving it.

The silencers consisted of a pair of steel drums that had been discarded from a chemical factory. The theory of these silencers was that expansion of the column of exhaust gas would reduce the rapidity of flow.

The same effect could have been secured by running the exhaust pipe into a pit filled with rounded boulders about 7 or 8 in. in diameter, as shown at the right in the sketch. The stones should be large enough to give sufficient space between them to allow easy exit of the exhaust gas, so as not to cause an excessive back pressure. A grating of wood or iron strips could be laid across the top of the pit.



ARRANGEMENTS FOR SILENCING NOISY EXHAUST OF A GAS ENGINE

Drainage from the bottom of the pit would have to be provided. The scheme would hardly be practicable, therefore, unless a drain, as shown in the sketch, could be attached. Located out of doors, as it necessarily would be, the pit would gather rain water, and unless this was drained off the obstruction would often lower the engine's efficiency by increasing the back pressure.

St. Louis, Mo. D. J. ALTIZER.

Editor's Note—The above description of silencing devices raises again the old question of the relative effectiveness and cost of home-made equipment as compared with manufactured equipment. Inasmuch as compact, effective and economical silencing devices have been placed on the market by several manufacturers, it would appear that anybody with a silencing problem should carefully compare the cost of these with the cost of labor and material and the efficiency of home-made devices.

Plant Operation Problems

What Happens When the Field Switch Opens?

ON PAGE 315 of the April 1 issue, C. D. B. asks a question regarding what happens when the field switch opens.

When two alternators operate in parallel, they must have the same frequency and the same terminal voltage and their prime movers must have drooping speed load characteristics. Figure 1 shows the speed load curve of two prime movers driving two alternators. The speed is plotted in frequency instead of r.p.m. The speed load curves of the prime movers are determined by their respective governors. If OC is the frequency at which the system is operating, the load taken by each machine may be obtained by projecting horizontally to intersect the speed load curves. OA is the load on machine No. 1 and OB is the load on machine No. 2 as both machines are operating at system frequency. If these machines were direct current generators and the field of No. 1 were strengthened and the field of No. 2 weakened so that the line voltage did not change, machine No. 1 would take on more load. But in the case of alternators No. 1 cannot take more load because its prime mover can deliver only the load OA at this frequency. Machine No. 2 cannot drop any load because its prime mover can deliver only the load OB at this frequency. Since both machines must always operate at the same frequency, therefore, the kilowatt load delivered by alternators in parallel cannot be shifted appreciably by means of the generator fields.

Changing the field current does, however, affect the current delivered by the two machines. Figure 2 shows the vector diagram for two similar alternators having a common terminal voltage V. Both machines are delivering equal currents I_1 and I_2 respectively which are in phase with the terminal voltage V. The resultant load current is their sum I_o which is in phase with V. As both machines have equal resistances and reactances, their respective internal voltages E_1 and E_2 are the same. (In the diagram, the machines are treated with reference to the external circuit, in which case the voltages and currents are acting in conjunction.)

If the field of generator No. 1 be weakened and that of No. 2 strengthened, the division of the kilowatt load is not affected; however, under these conditions, the internal voltage of No. 1 will decrease and the internal voltage of No. 2 will increase, but both machines must continue to have equal terminal voltage. When an alternator delivers a leading current, its internal voltage is less than when an alternator delivers a lagging current. A leading current in an alternator also tends to strengthen the field and a lagging current tends to weaken the field through armature reaction.

For generator No. 1 to operate with a reduced internal voltage, it must deliver a leading current making E_1 shown in Fig. 3, less than its previous value shown in Fig. 2. On the other hand, E_2 Fig. 3, is greater in magnitude than in Fig. 2, because generator No. 2 now delivers a lagging current. Also the leading current in generator No. 1 tends to strengthen its field and the lagging current in generator No. 2 to weaken its field through armature reaction. In both cases the change of flux produced by change in field current is opposed by armature reaction. The load current I_o cannot change in phase or in magnitude as the phase and magnitude of I_o are determined entirely by the character of the load which is connected to the system. Since I_1 and I_2 are equal, they must make equal angles with V so that their resultant will still lie along V.

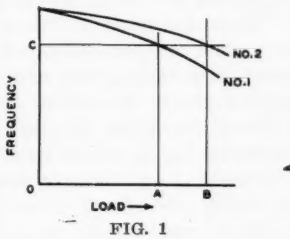


FIG. 1

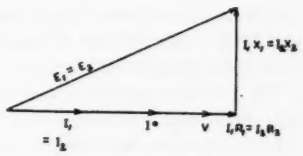


FIG. 2

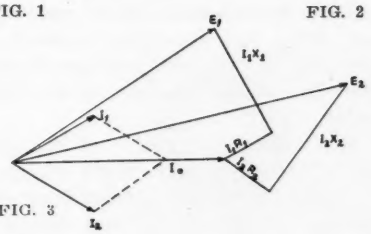


FIG. 3

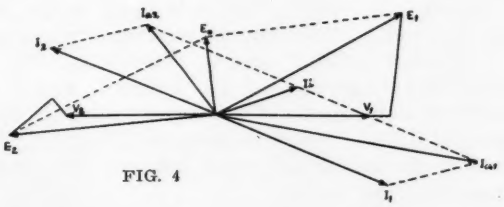


FIG. 4

It will be observed that each machine is delivering a larger current than it did before the field current was changed but the kilowatt output of each machine has not changed. This means that the heating (I^2R) loss in each machine has been increased without any compensating advantages.

Figure 4 represents the conditions existing between the two alternators with equal excitations and equal loads. This diagram is drawn with respect to the series circuit consisting of the two armatures. The terminal voltages, which are equal and in phase when considered with respect to the parallel circuit are opposite in phase when considered with respect to their own series circuit. V, E and I are respectively, the terminal voltage, the exciting voltage and the load component of the armature current. The subscripts 1 and 2 refer to machines 1 and 2 respectively. Since E_1 and E_2 are not in opposition, their resultant $E_o = E_1 + E_2$ is not zero.

The resultant, E_o acts through the impedances of the two armatures and produces a component current,

$$I_1 = \frac{E_o}{2Z}$$

in the series circuit consisting of the two armatures.

The synchronous impedance of each armature is $z = r + jx$. This component current or circulatory current lags behind E_o by an angle whose tangent is

$$\tan = \frac{x}{r}.$$

Since the ratio of the synchronous reactance to the effective resistance of an alternator is usually large, this angle is equal to at least 85 deg.

The current I_1 has a component which is in phase with E_1 and a component which is in opposition to E_2. It therefore produces generator power with respect to machine No. 1 and motor power with respect to machine No. 2. The power output of an engine or turbine depends upon its mean speed. Since the mean speed of the alternators does not change when they are displaced in phase, the power they receive from their prime movers is not altered by a change in phase. The effect of this interchange of current due to the phase displacement is therefore to slow machine No. 1 which leads and accelerate machine No. 2 which lags. That is the circulatory current tends to bring the rotors of the generators into synchronism which puts E_1 and E_2 in opposition. When this circulatory current is produced by an inequality of excitation voltages, it merely equalizes the terminal voltages mainly by its effect on armature reaction.

It is this apparent transfer of energy from one alternator to the other as a result of the circulatory current I_1 which makes the parallel operation of alternators possible. As shown in Fig. 4, machine No. 1 has an armature current I_{a1} which is equal to the vector sum of I_1 and I_1. The armature current of machine No. 2 is the resultant of I_2 and I_1. This is I_{a2}. The only actual currents are I_{a1} and I_{a2}. I_1 and I_2 and I_1 exist merely as components. The current delivered by the system is still the difference between I_1 and I_2. This is equal to the vector difference between the armature currents I_{a1} and I_{a2}.

In regard to a plant operating in parallel with other plants, the resistance and reactance of the transmission line add directly to the constants of the alternators in the plant. The effect of a given line impedance depends upon the ratio of its component parts as well as upon the load power factor. Any increase in line resistance when the load is either inductive or non-inductive will decrease the synchronizing action under most conditions. The effect of an increase in the line resistance is most marked where the power factor is low.

Due to hunting in the parallel operation of alternators, the excitation voltages are displaced in phase from each other during this period. The effect of this variation in the angular velocity of the system is to cause the terminal voltage to swing in phase when hunting occurs. This will not influence the hunting between the alternators which are in parallel but it will tend to start hunting between the alternators and any synchronous apparatus they supply. This may have caused the loss of the 500-kw. load in the plant referred to in the question.

In conclusion, it will be seen that when the field switch of one of the alternators operating in parallel is opened, the kilowatt load on each machine is not changed, but the current is increased considerably. When the field switch is opened a very large current will flow which may damage the machine, particularly if the load is large. The field switch should never be opened before the main switch is opened.

For a field switch to be opened in the parallel operation of alternators is a most unusual event in practice and it is almost unbelievable to think of any experienced operator doing such a thing. Under the circumstances, it is probably best to open the main generator switch and synchronize the machine again after the field switch is closed.

Ossining, N. Y. EDWARD W. JOHNSTON.

What Happens When the Field Switch Opens?

ON PAGE 315 of the April 1 issue, I noted the question asked by CDB, as to what happens when the field switch on one of two alternators is opened?

In my opinion, the generator with excitation will tend to carry the load and the other machine will just idle along. The switch may be closed without any damage to either machine. This is also true of synchronous condensers.

It will not be necessary to parallel the machine as when bringing up. The machine is already in phase and all that is necessary is to close the field switch.

One operator brings up the suggestion that if there was any danger of burning out a stator or rotor, the designers would have run two wires for excitation, these being in parallel so that if one should break the other would continue to carry the current.

I have had two or three cases where d.c. generators had been paralleled with wrong voltages; this generally resulted in a reversal of the smaller machine. I also knew of one case where the incoming a.c. machine was not properly synchronized and the smaller machine stator was burned out. This was probably due to the fact that the heavy surge grounded the machine windings. The arcing continued as long as excitation was on the machine. This also resulted in all machines going off.

Birmingham, Ala. GRADY H. EMERSON.

Unbalanced Three-Phase Motors

REFERRING TO the question on page 183 of the February 15 issue, regarding the unbalance of currents in a three-phase motor, it is my opinion that the trouble is in the stator windings. Several coils from one phase group may have been placed in an adjoining group when the motor was wound. One or two coils difference per phase usually will not cause much dissymmetry, but the resistance tests in this case indicate a rather marked unbalancing of phases. A physical count of the coils should be made to determine the actual number in each group, and if an inequality is found to exist the motor should be rewound.

Bozeman, Mont. EDWARD G. FISHER.

Counter-Bore Not Needed on Duplex Pump

WHY ARE the cylinders of a duplex pump not counter-bored?

A. Cylinders of a duplex pump are fitted with a metal lining which may be replaced at small cost and little work, thus doing away with any necessity of counter-boring.

New Equipment

New Silvertop Trap

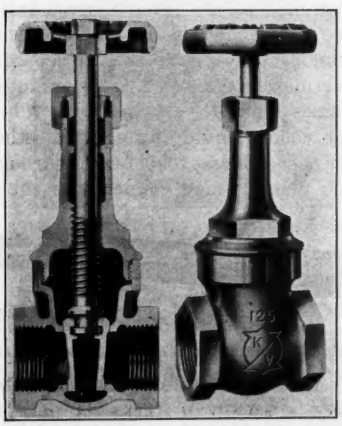
THIS ADDITION to the line of V. D. Anderson Co. is, as shown, of small size and light weight, requiring but little space. It is specially suited for use on small steam-using units in hospitals, hotels and light

SILVERTOP NO. 11 TRAP

industries process equipment and, for locations where special finish is desirable can be furnished chrome plated and polished. It can be used as elbow or straight line; removal of one bolt permits disassembling without disturbing pipe connections. Regularly with ½-in. connections or special with ¾ in.

Rising Stem Valve

KENNEDY VALVE Manufacturing Co., Elmira, N. Y., has placed on the market a new line of rising stem

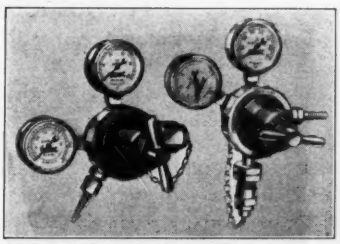


KENNEDY RISING STEM VALVE

bronze gate valves for 125-lb. steam pressure and 175-lb. water pressure, with solid wedge disc. The mechanism is simple, has no small parts and has a flexible connection between disc and stem so that the stem will not bind or spring when the valve is closed. Stem is of bronze composition having a large number of contact threads in the bonnet. The bonnet hexagon has been made extra large and close to the body so that, when a wrench is applied for installing or disconnecting, distortion will be avoided. Other features are a deep stuffing box with gland and square-section, molded packing rings, large non-heating malleable iron hand wheel and heavy, wide pipe-end hexagons with ample number of threads.

New Oxweld Regulators

LINDE AIR PRODUCTS Co., 30 East 42nd St., New York, N. Y., has recently added a new oxygen regulator and a new acetylene regulator to its line. These have been designed



TYPE R 48 OXYGEN AND R 49 ACETYLENE REGULATORS

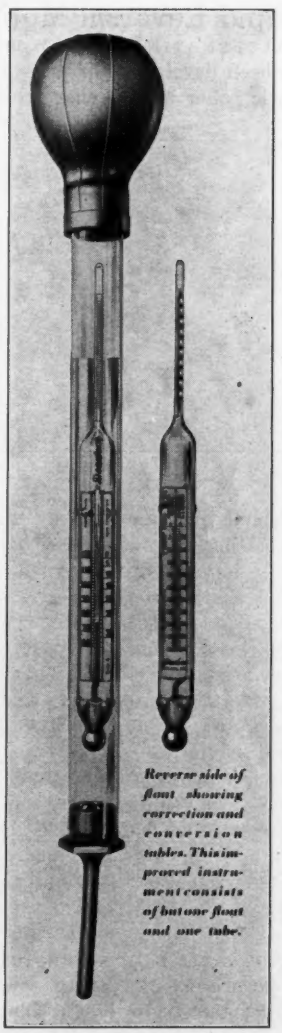
to provide lighter duty regulators, particularly for use with the Oxweld Type W-15 welding blowpipe in the sheet metal welding outfit.

Features of the design are: Bonnet held in place by a forged brass cap ring to give a non-leaking diaphragm; assembly and disassembly facilitated by a ribbed cap ring which assures an easy grip; monel metal stem detached from the diaphragm to provide smoothness in operation of the regulating mechanism; diaphragm of rubber composition and springs made of cadmium-plated steel; pressure adjusting screw with high thread pitch which permits rapid pressure adjustment; new type of safety release.

In the Type R-48 oxygen regulator the hose connection is for ¼-in. oxygen hose and, on the Type R-49 acetylene regulator it is for ⅜-in. acetylene hose; other size hose connections can be supplied, if required.

Dearborn Concentration Hydrometer

DEARBORN CHEMICAL Co., Chicago, Ill., is introducing this hydrometer for determining total dissolved solids in boiler waters, with several distinctive points. It has but one float and one tube, all scales being inclosed in the float. The hy-


Reverse side of float showing correction and conversion tables. This improved instrument consists of but one float and one tube.

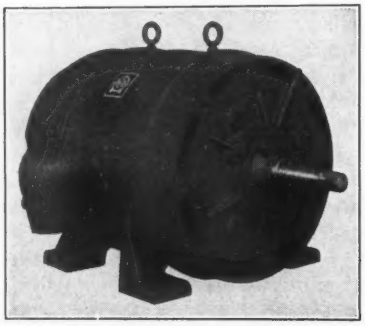
IMPROVED CONCENTRATION HYDROMETER

drometer is quick acting because a mercury thermometer is used and the space between the tube and the float permits the float to rise rapidly, substantial projecting knobs preventing friction of float against tube.

The instrument is compact, operation is so simple that readings can be taken in the cab of a moving locomotive, requires no special care in operation and will stand rough handling because of the single tube design, danger of float stem breakage being eliminated. It may be easily taken apart for cleaning, the float being withdrawn from the jar or tube by removing the lower rubber fitting, the outer rim of which is hexagonal in shape to prevent rolling when laid down. The float can be removed from the assembled instrument and operated in a separate container if desired.

Rapid Reversal Motor

ALTERNATING-CURRENT motors have been developed for driving automatic roller and catcher tables in



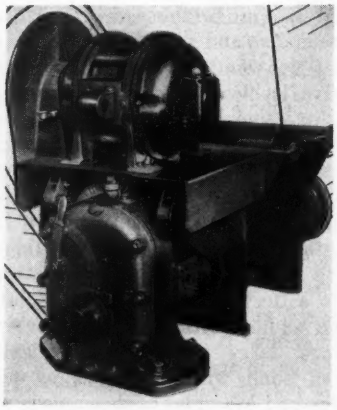
NEW RELIANCE MOTOR

sheet and tin plate mills by the Reliance Electric & Engineering Co. These motors are designed with torque characteristics to give rapid reversals and may be built to reverse forty times a minute. Low-inertia rotors are provided to keep reversing losses at a minimum. Enclosed against dirt, oil and moisture, with liberal radiating surfaces to keep the temperature rise normal, these motors have shafts extra heavy to withstand the continual, quick reversals. Internal and external fans are made of cast duralumin, with wide, heavy hubs and large keyways.

Air circulating within the motor never comes in contact with the outside atmosphere but is cooled by a system of internal and external circulation.

Stoker Front End

COMPLETE front-end assembly for stokers, a standardized unit including variable speed drive with base, low-speed, housed flexible coupling, adjustable motor base and hopper base with cleanout door is presented by Link Belt Co., 2410 W.

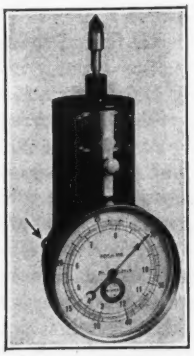


LINK BELT STOKER DRIVE

18th St., Chicago, Ill. It is offered in a variety of motor mountings to suit individual applications for the use of stoker manufacturers and users.

Registering Hand Tachometer

This new instrument, put out by Amthor Testing Instrument Co., shows, after removal from the shaft, the speed of the machine, thus doing away with the necessity for quick reading and possible mistakes. Also, the convenience for use in badly lighted places is evident. It has four speed ranges, each reading over the entire circumference of the dial in r.p.m., but these readings are easily converted into surface or belt speed in feet per minute. Features of construction are a balanced cross



AMTHOR HAND TACHOMETER

pendulum governor movement, dead beat action and hand calibration for accuracy.

Heat Exchanger for Dirty Fluids

HEAT TRANSFER becomes troublesome in processes such as are found in petroleum refineries, chemical plants and the like where fluids to be heated or cooled contain sediment, tar or dirt. Vapors from such liquids, when cooled in standard shell-and-tube exchangers quickly foul the tubes and shell, which reduces the effectiveness of the exchanger. Cleaning must be frequent to maintain satisfactory operation.

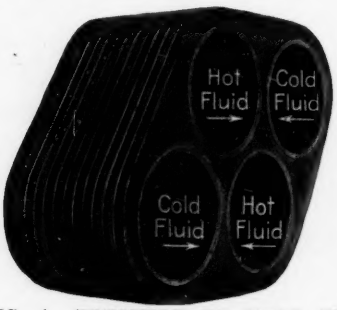


FIG. 1. PRINCIPLE OF HEAT EXCHANGE

In some cases, use of heat exchangers has proved impractical, in others low efficiency and expense of maintenance have made their use of doubtful economy. The new unit, herewith illustrated, has been developed to overcome such difficulties and is stated to have been uniformly satisfactory where installed.

This unit consists of 4 straight tubes, bonded mechanically by closely-spaced thin plates, Fig. 1. At one end, each pair of tubes is connected by a return member, this end being free to move with expansion or contraction due to temperature change. At the other end, tubes are expanded into a stationary head which carries inlet and outlet connections, Fig. 2. Hot water or liquid passes through one pair of tubes, the cooler liquid through the other pair, heat being transferred through the plates which connect the tubes.

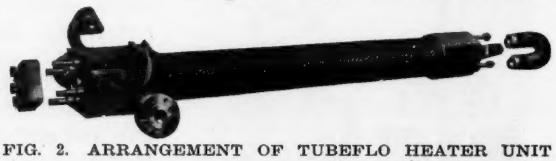


FIG. 2. ARRANGEMENT OF TUBEFLO HEATER UNIT

Units are interchangeable and may be set up in stacks for parallel or series connection for any desired

duty. Designs are available for pressures and temperatures up to high limits and in materials to withstand corrosive action where necessary.

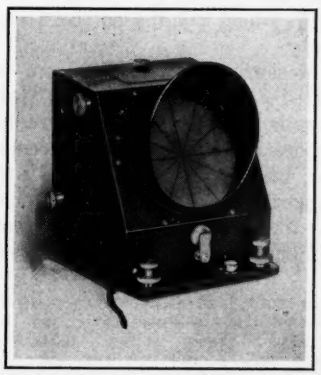
Sediment accumulation is prevented by high velocity and straight-through flow of fluids with no baffles to allow lodgment of particles. Because of the flow through a single passage, suspended matter is carried through the unit without depositing, so that, although the stationary head has access plugs for cleaning out the tubes, reports state that they are not used. One installation of 20 units handling dirty oil is reported as in use for 2½ yr. with no cleaning as against weekly cleaning for the equipment previously used.

All joints have spherical faces and cone seats to give line metal-to-metal contact without the use of gaskets and reduce possibility of leakage. As joints on hot side and cold side are independent, there can be no leakage between fluids.

Especially suited for handling sediment bearing oils and heavy fluids, the apparatus, known as G-R Tubeflo Section, Type K C is manufactured by the Griscom-Russell Co., 285 Madison Ave., New York, N. Y.

Vibrometer for Vibration Studies

To MEASURE vertical and horizontal vibrations simultaneously, the Electrocon Corp., 6 Varick St., New York, N. Y., has put on the market



THE DAVEY VIBROMETER IS 7 IN. HIGH AND WEIGHS 8 LB.

the Davey Vibrometer Model S-2. The instrument works on the principle of the seismograph, the main element being a weight suspended on springs. A small concave mirror is mounted on the weight and a beam of light traces out the exact path of the vibration on the ground glass scale, divided into 0.001 of an inch. Two standard models are supplied, S-2A which magnifies vibrations approximately 500 times and S-2B which magnifies 250 times. When supplied with a Neon tube the instrument may be used in conjunction with the Davey Portable Balancing Equipment.

Junior Unipulvo

CONDENSED FROM the larger edition but with all important features retained, this new equipment is offered by The Strong-Scott Mfg. Co., Minneapolis, Minn., for boilers from 75 to 150 rated horsepower. Fuel from the hopper is fed by a reciprocating-shoe feeder into the chamber of the swing-hammer rotor, grinding

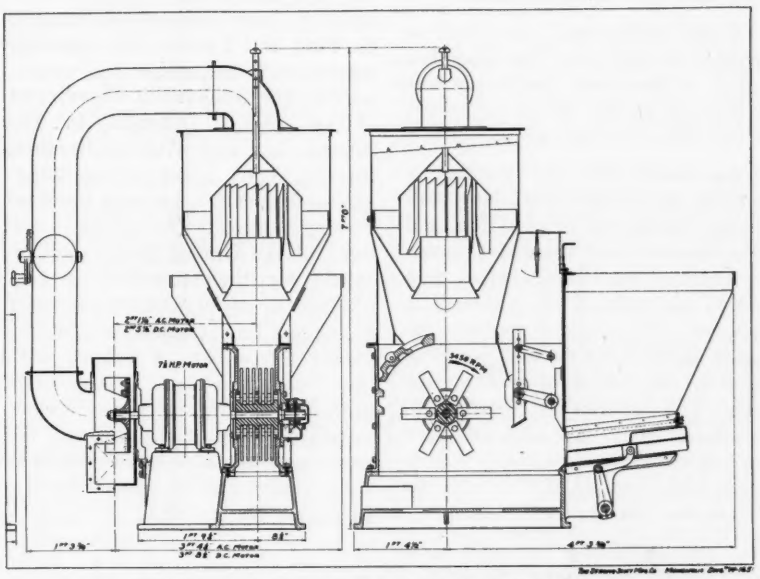


FIG. 1. CONSTRUCTION OF JUNIOR UNIPULVO

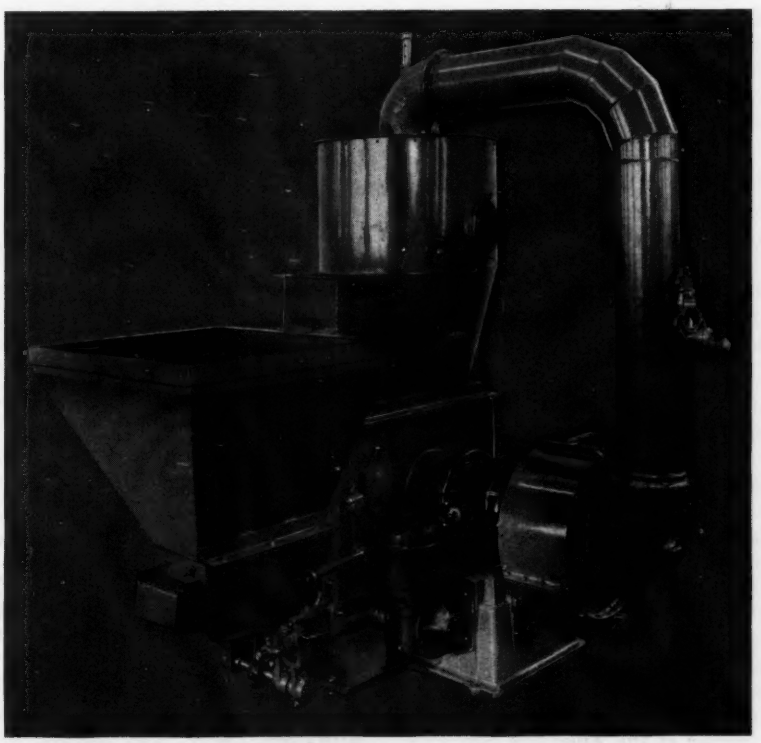


FIG. 2. ASSEMBLY OF JUNIOR UNIPULVO ON BEDPLATE

being effected by attrition over a bed of the same fuel, that lies dormant at the bottom where there is an ample pocket to receive tramp metal or rock, Fig. 1. The pulverizer chamber is air swept by a current admitted just in front of the hopper, the pulverized fuel being drawn upward into an expansion and separating chamber, where coarse particles are eliminated, to drop back into the pulverizer.

Fully pulverized, the fuel is carried through the fan chamber and on to the burner by the current of air. Incoming air is preheated in the boiler furnace walls.

As shown, Fig. 2, the unit is mounted on a single bed plate, both 7½-hp. motor for driving fan and swing-hammer and the ⅓-hp. motor for the fuel feed being bolted to a pad at the side of the pulverizing chamber. At nominal rating, the motor at 3450 r.p.m. will consume about 6 hp., handling mid-western coals. The capacity is from 200 to 750 lb. an hour. Air and fuel feed are regulated independently either automatically or by hand to give the CO_2 desired in the flue gases.

Gilbert E Ryder

GILBERT E. RYDER, vice-president of The Superheater Co., New York and Chicago, died Tuesday, May 17, 1932, at his home in Larchmont, New York, from a sudden heart attack.

In 1911, Mr. Ryder joined The Superheater Co. as a service engineer and was elected vice-president in charge of sales and service in 1921. With broadening of activities, the sale of superheaters for stationary power plants started under his direction.

Mr. Ryder was well known for his articles and speeches on fuel conservation and increase in power of locomotives through the use of superheated steam. For many years he participated actively in the affairs of several railway associations, in committees and as an officer. At the American Railway Association Convention in 1930 he finished his term as President of the Railway Supply Manufacturer's Association, culminating two decades of service in that association. He was also a member of the American Society of Mechanical Engineers.

He was born May 29, 1880, in Minneapolis, Minn., the son of Charles Gilbert and Mary L. (Gray) Ryder. His elementary schooling was received in the public schools of Sandwich, Ill., and Tabor Academy, Marion, Mass. He studied engineering at the University of Wisconsin and the University of Illinois. His railroad experience began with an apprenticeship on the Chicago, Milwaukee and St. Paul Railway (now Chicago, Milwaukee, St. Paul and Pacific) and included service as a machinist and draftsman in the mechanical department of that road at Dubuque, Ia., Ottumwa, Ia., and West Milwaukee, covering 5 yr. Later he was assistant mechanical engineer in the Fuel Testing Bureau (Briquette Division) of the United States Geological Survey, then served the city of Chicago as deputy smoke inspector in charge of locomotives, which placed him again in contact with the locomotive fuel conservation problem. Following this he became associate editor of the Railway Review (recently absorbed by Railway Age) from which he joined The Superheater Co. in 1911.

Thermo-Tel.

FOR DETERMINING and signaling temperatures by means of electric lights, this equipment has been developed by Uehling Instrument Co. When the temperature is within the desired range, a white light shows; if it rises above the limit a red light appears; if below the desired range, both lights will be out. The range can be set as desired as for instance 190 to 193 deg. Indications may be shown at a distance as well as at the point where temperature is taken. In form it is like a railroad semaphore, can be read at 200 ft. and is stated to be accurate to 0.1 deg. F. or less.

A.S.H.V.E. Summer Meeting at Milwaukee

PLANS HAVE been completed by the American Society of Heating and Ventilating Engineers for the Semi-Annual Meeting of the Society which opens June 27 for a three-day program at the Hotel Pfister, Milwaukee, Wis. The papers selected by the Program Committee cover a wide range of subjects and give the results of data collected at the Society's Research Laboratory and several cooperating institutions. An outstanding contribution is that of the Technical Advisory Committee which studied the comfort chart and comfort line, so that engineers will know how to use the effective temperature index and comfort charts.

GRAPHIC recording instruments are announced by the Esterline-Angus Co. having novel features. Spring clocks have all three springs wound by a single crank at the front and the clock units are removable so that they can be replaced in the field for cleaning or repair without putting the instrument out of service.

Arrangement is compact so that the rolls which drive the charts can be coupled together to synchronize the charts, this coupling being back of gears which fix the chart speed so that charts at different speeds can be coupled.

Either spring clocks, or alternatively synchronous motor clocks can give chart speeds from ¾ in. per hour to 12 in. per minute. For quantities which change rapidly, an instrument is furnished which has slow chart speed while values recorded are steady but, when sudden, rapid changes occur, the chart speed is automatically increased to 3600 times slow speed, returning to slow speed when conditions become steady.

Measuring instruments are insulated to withstand 5000 v. test; inkwells, specially shaped to reduce evaporation, and pens are removable; measuring elements are interchangeable in different cases which are for portable, flush or front switchboard mounting or wall type.

DOUBLE SEAL RING Co. is announcing a new one-piece ring for Diesel, gas and other combustion engines, having the same sealing at the gap as its two-piece ring. It is stated that the new design will prevent blow by in worn cylinders and that it is effective in air and ammonia compressors, also in pumps.

News From the Field

AMERICAN SOCIETY for Testing Materials has formed a new standing committee on standard methods of water analysis, for all types of industrial waters. Groundwork has been laid by Max Hecht, Duquesne Light Co., who is serving as temporary chairman. Initial consideration will be given to determination of oxygen, carbon dioxide, hydrogen-ion concentration; descriptions and data as to systems now in use will be welcomed by the committee whose address is 1315 Spruce St., Philadelphia, Pa.

R. H. SMITH of the Boston office of Reliance Electric & Engineering Co., has been made manager of the development engineering department, with headquarters in Cleveland. He will be succeeded by C. E. Robinson as manager of the Boston district office. The development engineering department handles industrial research and application for improvement of the use of motor drives.

E. A. MCCALLUM, representing Roots-Connersville-Wilbraham, Connersville, Ind., has removed from Los Angeles to San Francisco and is now located in Room 620 Hearst Building. B. T. Ehrnman is now located at 3300 Morganford Road, St. Louis: and C. B. Coldwell has relocated the Texas office at 307 Southland Life Insurance Bldg., Dallas.

AT ITS Terminal Power Station, Baltimore, Md., the Consolidated Gas, Electric Light and Power Co. has replaced an induced draft fan with a Type IV Thermix dust-collecting fan on a 1250-hp. boiler. This equipment is designed to produce 4 in. draft when handling the gases from the boiler developing 5000 hp. and to concentrate fly ash and cinders in part of the gas which is bypassed from the fan scroll to a cyclone where they are precipitated, the gas then being recirculated through the fan system.

BAILEY METER Automatic Control for open hearth furnaces will be displayed at the Iron and Steel Exhibition to be held at the William Penn Hotel, Pittsburgh, Pa., June 20 to 23. Diagrammatic layouts will show use to maintain furnace draft within narrow limits and to regulate fuel-air ratio for high combustion economy. H. M. Hammond, manager of sales and engineering, will be in charge.

FRICK CO., Waynesboro, Pa. is celebrating its 50th year in business as builders of ice-making and refrigerating machinery. It is now looking forward to the 100-yr. goal.

AT A RECENT meeting of the board of directors of The Pacific R & H Chemical Corp., El Monte, California, a subsidiary of The Roessler & Hasslacher Chemical Co., Inc., New York; C. K. Davis was elected chairman of the board; Dr. E. A. Rykenboer, president; F. S. Pratt, vice-president; A. Frankel, treasurer H. A. Schumacher, assistant treasurer; L. Rice, secretary; and J. L. Fahs, assistant secretary.

KENNEDY VALVE MANUFACTURING CO. announces that its new Chicago branch office and warehouse has been made a central distributing point for service to the eleven middle western states. This warehouse is in the Soo Terminal at 1306-1312 South Canal St., the stock carried including complete lines of the company's products.

H. S. WOODRUFF has been appointed engineer in charge of the design section of the newly formed Air Conditioning Department of the General Electric Co., according to an announcement by President Gerard Swope. Mr. Woodruff first came to the General Electric Co. in 1913 from Wayland Academy, taking a position with the Railway Control Design department. During the war, he was engaged in special work, particularly in the field of munitions manufacture. He reentered the employ of the company in 1926 and has recently been in charge of design development and production of new commercial products at its Schenectady Works Laboratory.

J. P. DU VAL, librarian at Pennsylvania Water and Power Co., Safe Harbor Water Power Corp. and the Engineers Club of Baltimore, was recently elected President of the Maryland Library Association.

LINDE AIR PRODUCTS CO. announces reduction in prices of Oxweld welding and cutting blowpipes, including type W-17 for welding, the CW-17 cutting attachment and type C-14 for cutting.

FOR THE summer of next year, a sectional meeting of the World Power Conference is planned to meet in Copenhagen, Stockholm and Oslo, June 26 to July 10. It will be devoted to energy requirements in large industrial plants and how they may best be met. The questions of generated vs. purchased power, generation of base load and purchase of peak power, coördination of hydraulic and fuel plants, supply of process heat requirements in various industries, electrical heating, use of power in heavy mechanical drives, energy problems in transportation for land and marine traffic will be covered. Importance of the problems to be considered to recovery of industrial prosperity and future success of industries are evident, hence the meeting should be of great interest and productive of results in the field of industrial power.

For the Engineer's Library

A COURSE IN ENGLISH for Engineers, by Carl A. Naether and George F. Richardson; 2 vols. cloth, 6½ by 9½ in.; Vol. I, 330 pp., Vol. II, 488 pp.; Ginn & Co., Boston, Mass., price, Vol. I, $2.60; Vol. II, $3.00.

PATHWAYS TO PRINT, by H. F. Harrington and Lawrence Martin, cloth 6½ by 9½ in., 443 pp.; D. Van Nostrand Co., Inc., 250 Fourth Ave., N. Y., price $3.50.

Most engineers wish that they possessed better command of both spoken and written English. Study of these two books together should give such men some idea of what they can do individually to attain the facility they seek. The two-volume work by Naether and Richardson covers the technical details of the engineer's language problems in a most compresenhive way. The book by Harrington and Martin, on the other hand, discusses writing primarily from the point of view of the free lance writer, whose principal problem is to write in such an interesting way that the reader will keep on reading his article. To many engineers the connection between these two books may not at first be obvious. Yet if the writer on engineering subjects assumes that his reader is always going to be interested naturally in his technical jargon, he takes many chances of having his writing ignored. For there are many occasions on which it is of value to write first in an interesting way and to let the technical facts be sugar-coated with a little humor or human interest.

One of the best examples of such writing we have seen recently was presented in the Dec. 15, 1931, issue of Power Plant Engineering, in an article that told how the monkey gland surgeons have revitalized electrical equipment. More of such writing in the technical press would help to eliminate jargon and would leave with the reader a unity of impression and a few definite ideas, a result seldom produced by detailed technical articles.

Professors Naether and Richardson in their first volume discuss in an interesting way the problems of the engineer when he writes: description, exposition, narration and the like. In doing so they apply many of the principles of interest creation brought out by the other book.

The second volume of A Course in English for Engineers covers in complete detail the whole subject of letter-writing from the engineer's point of view. This volume should be particularly valuable to any technical man. For instance, if he wants to find a good example of a letter written in answer to a complaint, he will find one accompanied by an analysis.

In short, taken together, these books should help any engineer who feels the need of more accuracy, completeness, economy and logic in his writing but at the same time wants to know how his stuff can be made more interesting.

ANALYSES OF FUEL, GAS, WATER AND LUBRICANTS. By S. W. Parr. Published by McGraw-Hill Book Co., Inc., New York, N. Y.; 6 by 8 in., cloth; 348 pages; price, $3.00.

Fourth edition of what is perhaps the most practical and comprehensive book of its kind for those who find it necessary to carry on considerable laboratory testing work or to become more familiar with these tests in order to interpret the results. Although much of the material is now duplicated by the test codes and

standard methods of the several national societies, the book gives a background of history which aids the inexperienced operator or student.

The book is divided into two general parts: Part I, lectures and Part II, laboratory methods. Rapid progress made during the last decade both in research and practice has been incorporated in this edition, the main purpose of the author being to facilitate a better understanding of modern technical literature. Dr. Parr died just before completion of his book and the revision was completed through his outline by Frances M. Parr.

THE "MECHANICAL WORLD" Electrical Pocket Book, 1932, Cloth, 4 by 6¼ in., 395 pages, illustrated. Emmott and Co., Ltd., 65 King St., Manchester, England. Price 1/6 (approx. 30c) net.

This little book is like an old friend—always welcome. Year after year it makes its appearance, never seeming to grow older, but always with something new between its covers. While the general form of its content is retained from year to year, new sections are usually added or chapters revised to keep it up to date. It is a most useful little pocket book for the man in charge of electrical equipment, covering both direct and alternating current practice. This year there are included four new and complete sections on Electric Welding and Cutting, Power Plant Operation, Electric Railways and Electric Lamps and Lighting.

NATIONAL ELECTRICAL CODE BOOK. By Arthur L. Abbott. First Edition. 5 by 7¾ in. Semi-flexible Fabricoid, 474 pages, illustrated. McGraw-Hill Book Co., Inc., New York, N. Y., 1932. Price, $3.00.

The purpose of this book is to enable the reader to grasp readily the general plan, scope, and intent of the National Electrical Code requirements, to present more or less detailed discussions of the rules wherever anything of practical value can be contributed by such discussion and to make the practical application of the rules clear and easily understandable. A word for word reprint of the code itself is not included, since copies are available to everyone at a nominal price. All requirements of the Code are given but some rules have been reworded to better serve the purpose of the book.

REWINDING DATA FOR DIRECT-CURRENT ARMATURES. By G. A. Van Brunt and A. C. Roe. First Edition. 6 by 9 in. Cloth. 212 pages, illustrated. McGraw-Hill Book Co., Inc., New York, 1932. Price, $2.50.

The purpose of this book is to give practical directions for taking and recording in a uniform and systematic manner sufficient data to enable a winder with a reasonable amount of experience to turn out a job that will give satisfactory service under the conditions for which it is intended. There have been a number of books published on the winding of armatures but only a few books are available which provide instructions for rewinding a machine. For this reason, this book should be a welcome addition to the library of any man who in the course of his work has occasion to rewind direct current armatures.

"FACTORS INFLUENCING FLOW OF NATURAL GAS THROUGH HIGH-PRESSURE TRANSMISSION LINES" is the subject of an extensive report No. R. I. 3153, W. A. Berwald and T. W. Johnson, and published by the U. S. Bureau of Mines. It presents the results of work done under the co-operative agreement between the U. S. Bureau of Mines and the Natural Gas Department of the American Gas Association.

Existing data on the flow of natural gas through pipe lines was collected and analyzed, flow tests and tests in actual pipe lines have been made and these results compared with the delivery calculated from several common pipe line flow formulas. Flow tests were made on 29 different pipe lines totalling 757 miles of pipe ranging from 6 to 22 in. in diameter, operating at pressures from 30 to 600 lb.

Results of the experimental test show that Weymouth's pipe line formula when applied to the larger diameter lines free from condensates and other foreign materials and operating under steady flow conditions favorable to accurate measurement, will give a volume within a few per cent of the measure delivered.

PIPING STANDARDS of the American Standards Ass'n are now being published and are for sale by the A.S.M.E., 29 W. 39th St., New York, N. Y. The following are included, all pressures for maximum saturated steam:

For cast-iron flanges and flanged fittings, pressures of 25 lb., 125 lb., 250 lb. For cast-iron screwed fittings, pressures of 125 lb. and 250 lb. For cast-iron long turn sprinkler fittings, pressures of 150 lb. and 250 lb. For malleable iron screwed fittings, pressure of 150 lb. For steel flanges and flange fittings pressures of 250, 400, 600, 900 and 1350 lb.

Also are included cast-iron flanges and fittings for maximum hydraulic pressure of 800 lb; taper and straight pipe threads; and scheme for identification of piping systems. Price of the set is $4.

AIR-FUEL RATIO from Exhaust Gas Analysis of Oil Engines, by V. L. Maleev, published by the Oklahoma Agricultural and Mechanical College, Stillwater, Okla., as publication No. 11 of the Engineering Experiment Station. The term "Air-Fuel Ratio" as used in connection with the internal combustion engine, means the amount of air in pounds per pound of fuel used by the engine. This ratio gives valuable information for improving the fuel injection. Procedure in obtaining experimental data necessary for the computation of the ratio, as outlined in the bulletin, is simple and does not require any special instruments or changes in the installation.

RATE BOOK of the N.E.L.A. for 1932 is ready for distribution at a price of $10 to members and $25 to non-members. Rates in all cities of 20,000 and over in the United States and Canada as of Jan. 1, 1932, are given, for all types of service. Rates for a number of smaller cities are included. With the book is given a mimeographed service to keep the information up to date.

STANDARD METHODS for Sampling and Analyzing Steam and Condensate in Corrosion Test Studies, by J. H. Walker, Detroit Edison Co., is a paper presented at the convention of the National District Heating Association, Pittsburgh, Pa.. It covers methods of sampling, determination of oxygen and carbon dioxide. Copies are available for those especially interested in the subject from D. L. Gaskill, secretary, N.D.H.A., Greenville, Ohio.

BACHARACH Optical Pyrometer, Holborn-Knurlbaum type, is completely described in Bulletin 296 just issued by Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

NO-OX-ID filler red for coating metal surfaces and preventing rust is described in a circular issued by Dearborn Chemical Co., 310 So. Michigan Ave., Chicago, Ill. It can be used alone or as a primer for a finish coat of paint or as rust preventive where wood contacts metal.

BULLETIN No. WT17 on Bonney Weldolets and Thredolets, containing complete description of the engineering principles of these welding fittings, also working data, tables of sizes, and illustrations of typical installations, has just been issued by Bonney Forge and Tool Works, Forged Fittings Division, Allentown, Pa.

FARRELL-SYKES high-speed gear units, their sizes, capacities, dimensions and application to drives are shown in Bulletin No. 425 issued by Farrel-Birmingham Co., Inc., 415 Vulcan St., Buffalo, N. Y.

AFTER COOLERS for Compressed Air, as built by Schutte & Koerting Co., Philadelphia, Pa., are described and illustrated in Bulletin 12-G, Supplement 1, which gives details, capacities and dimensions for vertical and horizontal types.

AMERICAN OIL Burner Assn., 342 Madison Ave., New York, N. Y., is issuing two publications of interest to manufacturers, dealers and users. The first is a Five-fold Trade Survey, covering dealer status as to lines handled, gas and stoker competition, schools using oil burners, oil and automatic heating, warm air survey. The second is by S. A. Raboy, a New York lawyer, 344 pp., on Law and Cases on Heating Systems and Devices, covering legal opinions and rulings as they apply to the oil burner industry.

FRE-FLOW type 260 strainers made by the Fisher Governor Co., Marshalltown, Ia., are described in Bulletin No. 23 issued by that company.

SWENDEMAN separator for removing oil and water from compressed air lines is illustrated and described, with tables of sizes and dimensions in a bulletin of the Leavitt Machine Co., Orange, Mass.

No. 7 BULLETIN on Stowe stokers, issued by the Johnson & Jennings Co., Cleveland, Ohio discusses the importance of maintaining a good fuel bed and essentials in a stoker to do this.

BEAVER power adapter for power operation of its No. 17 pipe threaders is described in a circular, Form 117, from The Borden Co., Warren, Ohio.

BULLETIN Z-9 of Liberty Mfg. Co., Jeannette, Pa., describes cleaners for small tubes such as condensers and heaters in sizes as small as ¾-in.

BULLETIN Z-10 on Liberty Cleaners for still tubes in oil refineries describes two types of motors, several types of heads and universal joints and polishing brushes. It is issued by Liberty Mfg. Co., Jeannette, Pa.

REPAIR Shop Lathes is a booklet issued by South Bend Lathe Works, South Bend, Ind., describing its new line in seven sizes designed especially for servicing operation, including besides usual lathe operations, mica undercutting, valve refacing, piston finishing and the like.

NICKEL Alloy Steel Castings are described in Bulletin 8-A issued by International Nickel Co., Inc., 67 Wall St., New York, N. Y. Properties of the alloys are given, requirements of design for good castings, the effect of addition of various alloy ingredients and heat treatments necessary.